

OPTIMIZATION OF FISCAL RETRENCHMENT POLICIES USING A SOCIAL
ACCOUNTING MATRIX MULTIOBJECTIVE LINEAR PROGRAMMING
MODEL: THE CASE OF NEW YORK STATE

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ABSTRACT

State finances continued to deteriorate over fiscal 2010, suffering from the cumulative impact of lower revenues, ballooning general fund spending and the general rise in the level of unemployment. The phasing out of the American Recovery and Reinvestment Act is likely to constrain even further the fiscal space of local governments throughout the country, potentially endangering a fragile economic recovery. In order to face rapidly rising budget gaps, forty states enacted mid-year budget cuts totaling \$22 billion for FY 2010. The fiscal retrenchment approach to budget policy appears to gain ground amongst embattled states, with governors proposing drastic cuts in their fiscal 2011 executive budgets to meet balance-budget requirements. The legacy of the 1970s tax revolts, having made tax hikes difficult to enact, also contributed to corner states into spending reduction strategies.

The study of cutback management has heavily focused on how and why reduction targets are adopted by state executives and legislators, as well as on their subsequent effects on local economies. The literature is however scarce on proposing a framework for efficient structuring of budget cuts at the state level. Stricken by uncertainty, many governors are driven toward across-the-board cuts, treating general fund expenditures as a fungible commodity. With states facing increasingly painful budgetary choices, weighting their implications and analyzing potential alternatives become critical to evaluate prospects for regional economic recoveries.

In this dissertation, a Social Accounting Matrix (SAM) Multiobjective Linear Programming (MOLP) model is proposed and applied to the case of New York State. The SAM multipliers provide a powerful instrument to evaluate the short-term impact of austerity measures while linear programming (LP) offers an optimization framework to close efficiently the state's budget gap. Attention focuses on the existence of several conflicting objectives that the decision maker tries to optimize simultaneously. Four procedures are introduced to solve the model: the augmented weighted Tchebycheff method, an elitist genetic algorithm, the weighted sum method and constraint programming.

The theoretical framework established in the following chapters as well as its application to the Deficit Reduction Plan proposed by Governor Paterson in fiscal 2009 show promising results. The model indeed converges to a set of Pareto optimal solutions that are by essence, more efficient with respect to growth, employment and labor income than the original plan. It constitutes one of the first practical applications of multiobjective optimization to policy design through a Walrasian general equilibrium framework.

BIOGRAPHICAL SKETCH

Born in Lyon, France, Thomas Hirtzig attended the Institut d'Études Politiques in his hometown, from which he received a Master of Arts in Political Sciences in 2009 with a concentration in Political Sciences. His interest for policy analysis and curiosity for economic methods brought him to Ithaca in the fall of 2009.

Thomas also studied at Seoul National University, Fukuoka University and Senshu University. His professional experience includes positions at EADS and JGC Corporation.

To Takako and my parents, for their patience, understanding and unfailing support

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Chapter I

INTRODUCTION

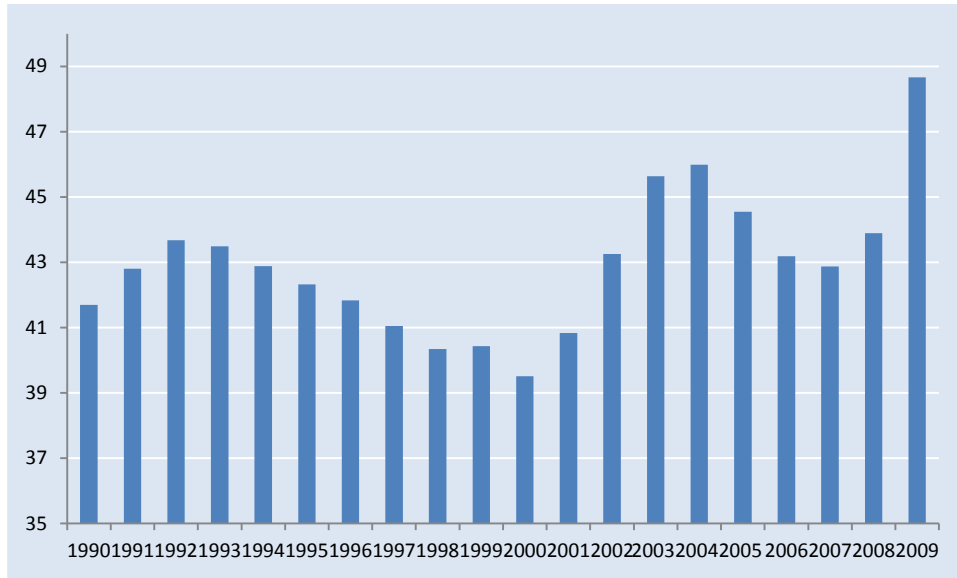
« Point de banqueroute, point d'augmentation d'imposition, point d'emprunts. Pour remplir ces trois points, il n'y a qu'un moyen : réduire la dépense au-dessous de la recette »

Anne Robert Jacques Turgot, Letter to Louis XVI, 24 August 1774

1.1 Background

The increasing decentralization of the provision of public services in the United States propelled the states – along with their subsidiaries, local governments – at the forefront of public finance in the federal system. States collected a yearly average of over forty percent of the nation's total public receipts during the 2000s, while when combined with local governments they have come to represent approximately seventy percent of national expenditures on non-defense public goods and services (Inman, 2010), forty-five percent of general government spending, eighty-eight percent of public investment and about ten percent of the U.S. GDP. At the state level, policy-making spans a wide range of services, from funding public schools to administering higher education institutions and penitentiaries and overseeing the development and maintenance of key public infrastructures. Moreover, states play a critical role in the health care system and enjoy extensive power in determining the level and nature of welfare benefits. Clearly, the influence of states on the U.S. fiscal policy cannot be ignored.

Figure 1.1. States collection of public receipts (in percent of total public receipts)

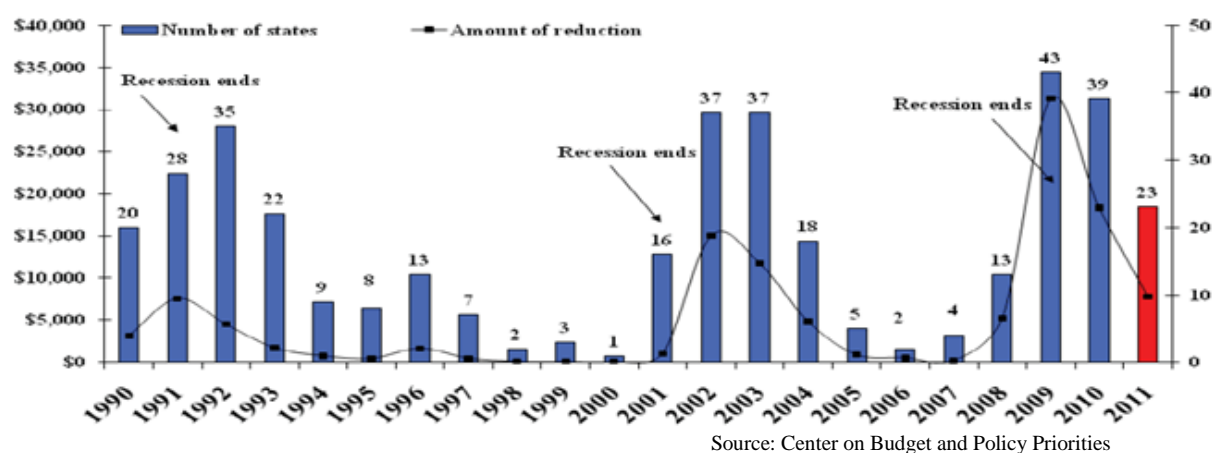


Source: U.S. Census Bureau, The 2011 Statistical Abstract

If their role in the provision of public services and in government spending has increased over the past decades, states have repeatedly experienced fiscal stress in the face of economic downswings. This was particularly true in the aftermath of the 2008 financial crisis and the recession that ensued. The National Association of State Budget Officers qualified FY 2010 as “the most difficult challenge for states’ financial management since the Great Depression” (NASBO, 2010:vii), a message largely echoed by governors across the political spectrum. State finances have indeed been affected by the scissor’s effect of declining revenues and increasing expenditures. A weak labor market along with stagnating income levels, ailing business activity and a widespread deleveraging of both households and firms took their toll on tax revenues.

The erosion of the fiscal space¹ has been particularly noticeable in states with large social welfare responsibilities, among which Medicaid, unemployment benefits and social assistance are prominent. A volatile tax base, in particular a heavy reliance on corporate or personal income taxes, has also been demonstrated to contribute negatively to fiscal stress (Dye and McGuire, 1991). Certain states have however fared relatively well during the downturn, especially those which could rely on revenues from severance taxes on natural resources².

Figure 1.2. Budget Cuts Made after Budget Enactment (\$ in millions)



The geography of the 2009-11 fiscal crisis of the states is thus not without parallels to the fiscal crunch of the early 1990s (Hansen, 1991), although their magnitudes are without comparison. States depending on tax inflows from hard-hit economic sectors – in 1991 as in 2009, the real-estate and financial sectors – suffered considerably more fiscal stress than their energy and natural resources-rich counterparts. This feature is

¹ The fiscal space can be defined as “the room in a government’s budget that allows it to provide resources for a desired purpose without jeopardizing the sustainability of its financial position or the stability of the economy” (Heller, 2005).

² Namely: Montana, Nebraska, North Dakota, Texas, West Virginia and Wyoming.

nowhere more prominent than in New York and New Jersey, two states which public finances have relied extensively and increasingly on the performance of the financial industry (Deitz et al., 2010).

Despite these similarities, the response and support of the federal government differed sensibly when comparing 1991 and 2009. The depth and the breadth of the fiscal crisis urged the federal government to relieve the crumbling finances of the states, a move that broke down a tradition of non-intervention established after the panic of 1837³ (Inman, 2003). Another divergence has been the method used by states to tackle their burgeoning deficits. In the past, states tried to shield K-12 and higher education, Medicaid, public safety and aid to local governments as much as possible from cuts. The dynamic somewhat shifted with the recession that took place in 2001, when state governments relinquished revenue measures in favor of fiscal retrenchment.

1.2 The Importance of Mid-Year Budget Cuts

The magnitude and likelihood of budget cuts swell when states carry out large episodes of budgetary adjustments during their fiscal year to close a widening budget gap. Mid-year budget cuts, as these episodes are called, are a clear sign of fiscal distress.

³ In 1837, eight states (Arkansas, Illinois, Indiana, Louisiana, Maryland, Michigan, Mississippi and Pennsylvania) would default on the debt they accumulated to expand their railroad and canal infrastructures. The federal government, which previously assumed the charge of the debt taken by states to finance the revolution and bailed out the District of Columbia from a debt of \$1.5 million in 1836, refused to intervene.

Definition 1.1. *Mid-year budget gaps:* they arise when the revenue collections forecasts provided by state budget officers prove inferior to the financing needs of the government for the remainder of the fiscal period.

Given the complex nature of econometric forecasting techniques and their relative inaccuracy in a context of financial crisis, mid-year budget gaps are likely to arise because (i) revenue collection or (ii) spending demands have been underestimated⁴.

This is a source of complexity for financial management in times of economic crisis. Due to their constitutional obligations to maintain a balanced budget on an annual or biennial basis, states have indeed less leeway than the federal government in managing deficits. Fiscal measures taken by the states to address budget gaps can thus exacerbate economic downswings and play a pro-cyclical role in regional economies⁵, pro-cyclicality being commonly defined in the literature as a violation of the tax smoothing principle of holding constant tax rates and discretionary government spending as a fraction of GDP over the business cycle (Kaminski, Reinhart and Vegh, 2004; Alesina and Tabellini, 2005). Pro-cyclicality is of particular concern in the case of mid-year budget gaps, since they usually follow fiscal year deficits. The state government, having already exhausted its most effective policies to reap low-hanging fruits, is confronted with difficult policy choices to eliminate mid-year budget gaps, even though their size is comparatively limited. Moreover, raising revenues is

⁴ For a discussion of econometric models applied to state and local government revenue forecasting, see Grizzle and Klay (1994).

⁵ An empirical work for the European Union is Wibbels and Rodden (2006).

politically and institutionally difficult during the fiscal year. Without large revenue increases, balancing strategies are amputated from a very powerful tool. Thus remain at the disposal of governors and legislatures a limited toolkit to (i) balance their budget and (ii) cushion the bust in the economy:

- *Prevention measures*: the so-called rainy-day funds, an innovation of the 1980s;
- *Temporizing*: delay capital expenditures;
- *Gimmicks*: using “off-budget” funds, underfunding pensions or selling assets;
- *Balancing*: decreasing spending (increasing revenues being impossible).

Given the often pro-cyclical nature of the fiscal policy choices selected by states during episodes of acute economic crisis and their debilitating effects on macroeconomic stability, economists have taken a keen interest in the study of budgetary decisions and their impact on regional economies. Mimicking the macroeconomic debate, discussions have focused on the respective merits of fiscal retrenchment and tax increase in mitigating economic contractions and subsequently assisting the recovery. As Johnson (2010) points out, the crux of the matter is to investigate “how can [states] balance their [...] budgets with the *least possible harm* to their still damaged and fragile [...] economies”. Proponents of tax increases usually refer to the influential paper of Joseph Stiglitz and Peter Orszag (Stiglitz and Orszag, 2001), who argued that “tax increases would *not* in general be more harmful to the economy than spending reductions. Indeed, in the short run (which is the period of concern during a downturn), the adverse impact of a tax increase on the economy may,

if anything, be smaller than the adverse impact of a spending reduction [...]”. More than a hundred economists from New York State, including Robert H. Franck, Christopher Barrett, Susan Christopherson, Lourdes Beneria and Erik Thorbecke of Cornell University, urged Governor David Peterson to adopt this position in an open letter published in 2008⁶. On the other side, the German treasury and the Bundesbank introduced in the 1980s the counterintuitive idea that fiscal contraction can actually be expansionary (Fels and Froehlich, 1986). Giavazzi and Pagano (1990) found supporting empirical evidences for Denmark and Ireland. The mechanism is explained by lower expectations of future tax liabilities which would boost private consumption and investment. The “moderate” approach to this theory is that although it is highly unlikely that fiscal contraction is actually expansionary⁷, its negative impact on mid- to long-term economic growth is rather modest.

1.3 Research Proposal and Structure of the Dissertation

This dissertation does not to try to gain insights on the respective economy-wide impacts of various policy mixes and to identify accordingly the most efficient arrangement in terms of revenue and expenditure measures. Its purpose, rather, is narrowed to the management of fiscal retrenchments using mathematical

⁶ http://www.fiscalpolicy.org/FPI_Release_EconomistsOnFiscalPolicy_December2008.pdf Accessed October 5, 2010

⁷ In such a case, the aggregate government spending multiplier would be negative. The hypothesis has been discarded by Barro (1987) in his exposition of a neoclassical framework for fiscal policy. We may remark here that because we use a Social Accounting Matrix in this dissertation, government spending multipliers are postulated to be positive. Moreover, SAM is a static model, and therefore does not take into account the anticipations of economic agents.

programming. The research project has thus two components. The first one consists in the development of a quantitative structural model to analyze, compare and optimize the policy impact of mid-year budget cuts on an economic system. The second undertaking is the empirical application of the model to New York State.

A Social Accounting Matrix Multiobjective Linear Programming (hereafter SAM-MOLP) model is used to ascertain whether or not it is possible for state governments to improve the structure of their budget cuts so that their incidence on the regional economies of interest is minimized. The MOLP framework allows a careful and systematic investigation of the best set of alternatives available to policy-makers with respect to the values taken by key macroeconomic variables in general equilibrium, as determined by shocking the underlying Social Accounting Matrix. The issue is thus tackled simultaneously from a policy design perspective thanks to multiobjective optimization and from an economic impact perspective through the social accounting matrix. Because our interest is limited to discretionary savings – on which the state’s executive and legislative powers have absolute decision power – the scope of the study is limited to the management of the general fund notwithstanding the federal funds, other state funds and bonds. This leaves us with the revenues not earmarked for specific items, or 41.7% of the \$1.59 trillion spent by state governments in FY 2009 (NASBO, 2009).

Definition 1.2. *General fund*: the general fund is the most important operating fund of states. According to the Division of Budget of New York State⁸ “it receives all State income not earmarked for a particular program or activity and not specified by law to be deposited in another fund. State income for financial plan purposes consists of moneys deposited to the credit of the General Fund during the fiscal year from current revenues (taxes, fees, and miscellaneous receipts including certain repayments of State advances) and transfers. General Fund income finances disbursements from its two operating accounts — the Local Assistance Account and the State Purposes Account — and transfers to other funds”.

The remaining of this chapter is dedicated to the presentation and justification of the methodology selected for this research. The first part of the dissertation (Chapter 2 and Chapter 3) aims at providing the reader with a description of the fiscal situation that the states and New York in particular found themselves following the Great Recession. In the second part, the core of the dissertation, Chapter 4 delineates the general framework for a social accounting matrix multiobjective linear programming model and its application to policy analysis. Lastly, Chapter 5 illustrates an empirical application of the general framework proposed in Chapter 4.

⁸ http://www.budget.ny.gov/citizen/financial/glossary_all.html#g Accessed November 6th, 2011

1.4 Methodology

Perhaps because of its traditional definition as the scientific study and analysis of “how societies use scarce resources to produce valuable goods and services and distribute them among different individuals” (Samuelson and Nordhaus, 2010:4) economics has repeatedly been proven to constitute a field of choice for mathematical programming applications. Thijs ten Raa (1994) even summarizes the economic problem as “the maximization of some objective subject to constraints”, a definition that is not without recalling that of linear programming. This remark comes as an echo to the seminal textbook authored by Robert Dorfman, Paul Samuelson and Robert Solow in 1958 entitled *Linear Programming and Economic Analysis* which argues that “there is no more frequent problem in economic analysis than the inquiry into the characteristics of the “best” allocation [of various factors of production]”. Indeed, the issues of allocation and efficiency lie at the core of economic theory.

In order to systematically represent and analyze its object, traditional economic analysis formed early on the assumption that agents – in particular consumers and firms – are instrumentally rational⁹. Agents are then typically expected to behave such that they attempt to maximize a certain objective function subject to some constraints. Mathematical optimization offers a powerful tool to model such behaviors (Intriligator, 1971). The concept of rationality quickly extended to policy-making and policy analysis along with its corollary, efficiency, the production of “the highest

⁹ the *Zweckrational* of Max Weber (1921).

combination of quantity and quality of goods and services given technology and [scarcity]” (Samuelson and Nordhaus, 2010:5). For policy makers, the utility function of consumers or the profit function of firms is mimicked by introducing a welfare or social utility function that the policy maker ought to maximize. In public economics, the government can maximize said welfare function through (i) allocation, (ii) distribution and (iii) stabilization (Musgrave, 1959). Because in a democratic and open political system the government acts on behalf of the people it represents, the government’s objective function is both unique and perfectly representative of the society’s preferences, at least theoretically.

Numerous authors came to criticize this idea. As Kenneth Arrow (1950) pointed out, the aggregation of ordinal preferences is a rather complex endeavor during which desirable properties may be lost. Moreover, it is unclear whether or not defining an aggregated objective function – granted it exists – is actually possible. Beyond mathematical difficulties, single objective linear programming (LP) –problems with a unique objective function to optimize – may be considered too simplistic and consequently unrealistic to model often complex and multi-faceted policy decisions. Not only governments rarely aim at achieving a single defined objective through their policies but also seldom can they be represented a monolithic entity. National governments usually keep a close eye on indicators reflecting the evolution of the real economy (GDP growth, unemployment rate, private capital formation, trade balance) and the nominal economy (inflation) as well as politically sensitive indicators of public finance management (debt burden, budget deficits). Additional layers of

complexity are added as the government legislates in the environmental area and as sustainability becomes a target of increasing importance for most policies.

Optimization using linear programming has however come a long way since it was first introduced by the Soviet mathematician and economist Leonid Kantorovich¹⁰ (Kantorovich, 1939) and refined by George Dantzig. Of particular interest to this dissertation is the development a large body of techniques dealing with the existence of multiple objectives that must be simultaneously optimized: multiobjective optimization (MOO)¹¹. Multiobjective optimization finds its root in three domains¹²: equilibrium and welfare economics, game theory and pure mathematics. The existence of multiple objectives for a given issue is a necessary condition to use MOO, but it is not sufficient in itself. Indeed, at least two of the objectives defined must be conflicting for the multiobjective problem to be non-trivial. That is, they cannot simultaneously reach their optimal levels. In general, two objective functions are said to be conflicting when a decrease for one objective leads to an increase in the other objective (Collette and Siarry, 2003). The classical example of conflicting objective functions is environmental protection and industrial activity.

In the case of a public investment and fiscal policy, the decision maker typically wish to achieve several objectives simultaneously including (i) maximizing employment, (ii) maximizing output, (iii) maintaining or improving equity, (iv) increasing or

¹⁰ He received the Nobel Memorial Prize in Economics in 1975 along with Tjalling Koopmans for his contribution to the theory of optimum allocation of resources.

¹¹ Also called vector optimization.

¹² For a historical perspective on MOO, see Stadler (1979) and Stadler and Dauer (1992).

protecting tax revenues and (v) limiting inflation. These objectives, however, can be conflicting. For instance, increasing the number of jobs created by a project may require the policy maker to forsake potential tax revenues, or growth in output may come at the price of higher inflation. Traditional monobjective linear programming, by using a single objective function, conceals the existence of competing objectives in policy design, and calls to the decision maker's subjectivity to take into account existing tradeoffs that were not mathematically formalized. Multiobjective optimization offers a powerful tool to maximize – or minimize, or both, according to the problem at hand – “at best” the various objective functions faced by policy makers.

Given the characteristics enumerated above, it can be reasonably argued that multicriteria decision making¹³ – of which multiobjective optimization is a part – is a valid methodology to investigate policy making issues. We believe it is especially appropriate in the case public policy analysis dealing with spending programs, where a wide variety of factors must be taken into account, ranging from employment to pollution and the formation of private capital. The approach is not without its limitations though, and a devastating critique came from Robert Lucas' seminal paper on estimated econometric models (Lucas, 1976), an area in which there was much hope for MOO. In substance, Lucas observed that these models are ill-equipped to assess the economic impact of alternative policies, as the policy of reference is already “built” into the estimated econometric model when the equations structuring it are first

¹³ Multicriteria decision making gathered other methods, such as the Analytic Hierarchy Process or goal programming.

determined. Because econometric models are so popular in policy evaluation, this may explain why applications of MOO to that purpose have been quite marginal.

In this dissertation, it is proposed to circumvent the problems associated with the use of reduced econometric models by utilizing a class of economic model where the behaviors of agents and policy levers are isolated from the structure of the economy. Two classes of model fit the role: the input-output framework – and its social accounting matrix (SAM) extension – and computable general equilibrium (CGE) models. The present research restricts itself to the social accounting matrix.

Although the tools employed hereunder are somewhat new to the study of fiscal policy and to the issue of budgetary management, the problematic that frames the scope of this dissertation is not: it aims at optimizing policy decisions through the mathematical determination of a certain number of policy levers (the exogenous variables) and the values taken by associated policy objectives (the endogenous variables). In quantitative economic policy jargon, the model will be determined by four types of variables (Tinbergen, 1952), namely:

- *Data*, assimilated to exogenous variables;
- *Policy Instruments*, the variables determined by the decision maker;
- *Target variables*, representing some measures that the decision maker wishes to optimize;
- *Irrelevant variables*, contributing to the construction of a realistic picture of the economy but of little interest to the particular policy under scrutiny.

The mechanics of the resulting model is straightforward: the social accounting matrix provides a plausible economic system to quantify the effects of policy interventions (captured by the target variables), whereas the algorithm of the multiobjective linear program searches for efficient policies in terms of the criteria identified by the decision maker.

The work laid out in the following pages is therefore prescriptive in nature. It attempts at providing policy makers in New York State – and possibly other states – with a tool to analyze the economic consequences of their budgetary decisions, in particular fiscal retrenchment policies. The study of cutback management has up until now heavily focused on how and why reduction targets are adopted by state executives and legislators, as well as on their subsequent effects on local economies. The literature is however scarce on proposing a framework for efficient structuring of budget cuts at the state level. Stricken by uncertainty, many governors are driven toward proposing across-the-board cuts, treating general fund expenditures as a fungible commodity. With states facing increasingly painful budgetary choices, weighting their implications and potential alternatives become critical to evaluate prospects for recovery. This dissertation hopes to fill the gap.

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Chapter II

FISCAL STRESS AND FISCAL RETRENCHMENT AMONG STATE GOVERNMENTS

This chapter provides an overview of the fiscal crisis that struck the states in the wake of the Lehman bankruptcy and the policies they implemented in order to respond to it. It begins with a discussion of the causes of the fiscal crisis and the implementation of cutback management since the 1970s and then analyzes state fiscal conditions, tax policy, spending policy, and policies affecting local governments. This chapter describes the unstable fiscal environment states are navigating since the early days of the recession in 2007. It brings a particular focus on the fiscal years 2009 and 2010 as an immediate prelude to the mid-year cuts proposed by governor Cuomo in FY 2010 which will be at the heart of the modeling exercise of this dissertation.

In the case of deficits as much as in the case of tax revenues or spending policy, it is important to note that the aggregate figures discussed in the following sections can be heavily influenced by a limited number of large states. Cutbacks were much more severe in certain states than others, while all states did not enter the recession in the same fiscal position. Chapter III will give us the opportunity to detail the case of New York State.

2.1 The Causes of the Fiscal Crisis

2.1.1 Optimal federalism: the example of the 2000s

Before attempting to fathom what went wrong for the states following the recent recession, it is important to obtain a better understanding of the place of states in the fiscal architecture of the United States. Indeed, because each person in the United States falls within the jurisdiction of several public authorities, the study of a normative public sector theory becomes all the more complex. The founding principles of the discipline remain unimpaired though: government interventions – no matter the place of the public entity in the layer of jurisdictions – are justified in the presence of market breakdowns. In addition, the ultimate goal of government intervention is social welfare maximization, which takes on several aspects: efficiency, equity and stabilization of the economy during the business cycle. If these fundamental aspects of expenditure and tax policy are clear enough in theory, their applications in a real world characterized by a multi-layered federalist structure and the mobility of citizens is challenging. The theory of fiscal federalism has attempted to bring solutions to this conundrum by proposing to sort the functions of government and the people among the existing jurisdictions (Tiebout, 1956; Stigler, 1957; Break, 1967; Oates, 1972).

The intricacy of the theory of public finance did not prevent the emergence of a working fiscal and budgetary federal structure in the United States. The system

repeatedly proved satisfying and efficient during the post-war period, noticeably in the mid-80s, mid-90s and mid-2000s. At the state level, the efficient management of government finances corresponds to the determination of a level of spending, including transfers, such that the marginal cost of the service provided equals its marginal benefit (Inman, 2010). Thanks to fiscal federalism, U.S. states tend to perform well this function in normal time, with regular programs financed through taxes and capital expenditures through the issuance of long-term debt. Figures from the U.S. Census Bureau (2010) suggests that annual state spending averaged \$4,430 per capita in fiscal 2006, more than the \$3,236 per capita collected. However, once transfers from the federal government are taken into account (\$1,290 per capita), the gap vanishes, resulting in a surplus of about 2% of current spending (\$96 per capita). As Inman (2010:15) notes:

“In FY 2006, states were spending money on appropriate state functions, raising most of their money with efficient resident-based taxes, and running small fiscal surpluses on the current accounts. For the most part, the federal government provides assistance for those state services where there are arguably significant inter-state spillovers and does so with appropriate price-based subsidies. By most measures, states were fulfilling their assigned role in our federal system of public finance in FY 2006”

Using the example of the mid-2000s, it would thus appear that during periods of economic recovery and expansion, states tend to bring their budget in balance and

even record some surplus. This leads to ask the question: how much of the fiscal woes underwent by states in the recent economic contraction can be explained by factors that are beyond their control and how much can be traced back to pre-existing structural imbalances?

2.1.2 The main factors of the fiscal crisis

THE RECESSION

The single most important contributor to the states fiscal crisis is certainly the recession, which lasted 18 months from December 2007 to June 2009 (NBER, 2010). In length, this episode of economic contraction outlived the previously longest postwar recessions of 1973-75 and 1981-82. The induced fiscal stress, fuelled by shrinking tax revenues and growing spending in social program, indiscriminately hurt states across the country, even if some regions resisted longer than others. This is a major difference with the national recession of 1990-91 where the severity of the crisis impacted the Northeast and California alone.

At the national level, the recession of 2007-09 was the deepest experienced by the United States since the Great Depression. The sole statistic of unemployment is illustrative: at the height of the boom, in January 2006, the national unemployment rate was only 4.7%. It more than doubled to 10% in the fourth quarter of 2009, and has fluctuated around 9% ever since (BLS, 2011). And the toll taken on state public finances has been substantial.

The annual average unemployment rates rose in 2009 in all states (BLS, 2010). Increases were particularly strong in Michigan and Nevada (+5.3 and +5.1 percentage points respectively) and in 7 other states¹⁴ which recorded changes larger than 4 percentage points. Statistics were even grimmer when it came to stocks: 14 states and the District of Columbia had unemployment rates larger than 10%, with 9 states establishing new records in their annual series. This followed an already calamitous year for the job markets. Indeed, 39 states and the District of Columbia already recorded statistically significant unemployment rate increases, even though the change was of lesser magnitude than in 2009 (BLS, 2009). Certain states, such as Nevada and Florida, even witnessed a first bump in their unemployment rates as early as 2007 while the trend of job creations in 40 other states and the District of Columbia stalled (BLS, 2008).

For comparison, when the U.S. economy moved into a recession in 2001, 42 states and the District of Columbia experienced rising unemployment rates (BLS, 2002). The impact of the recession was however far softer than in 2008-10. The worst performer, North Carolina, had the largest increase at 1.9 percentage points and only 18 states reported rate increases of 1 percentage point or more. If the trend persisted in 2002 for 47 states and in 2003 for 34 states, the magnitude of the increases remained relatively small, and as the economy gathered speed in 2004 annual average unemployment rates rapidly declined. During the recession of the early 1990s, the average unemployment

¹⁴ Alabama, California, Florida, Indiana, North Carolina, Oregon and South Carolina.

rates increased in 31 states and 26 states in 1992 and 1991 respectively. Employment peaked up as soon as 1993, with 37 states recording lower unemployment rates.

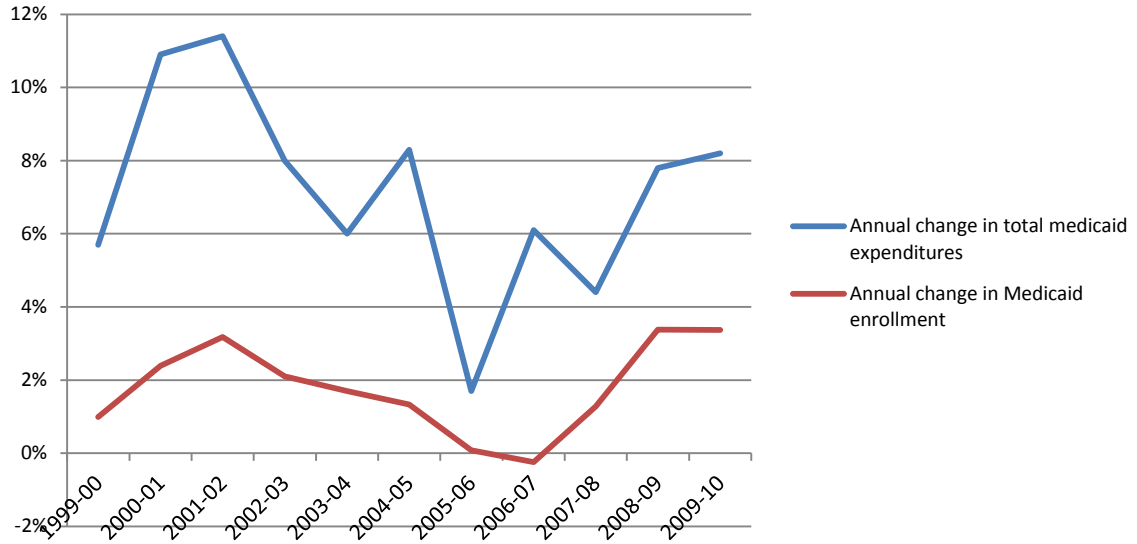
The exceptional nature of this crisis has unsurprisingly taken an extraordinary large toll on the states' finances, both from the revenue and expenditure point of view, as we will see in a subsequent section.

MEDICAID

If the poor macroeconomic performance of the United States since 2007 explains an important part of the budget deficits and growing debt of most states, another structural factor plays its part in the widening of budget gaps. With Medicaid enrollment growing by more than 17% to 50.3 million beneficiaries since the start of the recession, states have had to buff up their spending to support the program. This is all the more true that Medicaid, with 22% of total spending in FY2010, represents the single largest item on the states' budgets¹⁵. More than the recession and the increased in poverty it caused, the growth of Medicaid has been propelled by exploding health care costs and by the progressive withdrawal of higher FMAP support provided by the federal government through the Recovery Act.

¹⁵ Up from 9.95% in 1988 and from 15.46% in 2000.

Figure 2.1. Evolution of enrollment and state expenditures in Medicaid



Source: NASBO for Medicaid expenditures, the Kaiser commission (2011) for enrollment

FEDERAL MANDATES

The supremacy clause of the Constitution ensures that when a legislative action is taken by the federal government in an area where it has concurrent powers with the states, the latter must comply with the piece of legislation it enacted. These laws, known as federal mandates, bore a costs for states, even though unfunded federal mandates are now less common than they were in the 1980s and early 1990s¹⁶ (Sidlow and Henschen, 2005). In the 1980s indeed, the Advisory Commission on Intergovernmental Relations reported that the costs of unfunded mandates were actually increasing at a faster rate than federal assistance, with 63 statutes concentrating the bulk of the additional compulsory spending (ACIR, 1993). Among

¹⁶ The Unfunded Mandates Reform Act of 1995 requires the Congressional Budget Office to estimate the cost of intergovernmental mandates exceeding \$50 million. This does not mean however that mandates costing to state or local governments are prohibited.

these, 25 were mandated during the 1970s and 21 during the 1980s. By comparison, 62 intergovernmental mandate costs exceeding the \$71 million legal threshold were identified by the Congressional Budget Office between 2000 and 2010, but none had the magnitude of the Drinking Water Act Amendments of 1986 (between \$2 billion and \$3 billion), the Asbestos Hazard Emergency Response Act of 1986 (\$3.15 billion) or the Water Quality Act of 1987 (approximately \$12 billion) (Dilger and Beth, 2011). For the sole fiscal year 1991, ACIR estimated that federal mandates cost between \$2.2 billion and \$3.6 billion to state and local governments, which contributes to explain why they may have been singled out as a source of additional fiscal stress during the recession of the early 1990s.

Even though the cost of federal mandates for states, in particular those concerning Medicaid, has not been the subject of a thorough study, it is likely that they have not contributed significantly to the deterioration of the states' public finances over the last decade.

SCHOOL ENROLLMENT

As will be detailed hereunder, the second biggest item of spending for state governments and the largest one for local governments is elementary and secondary education. Consequently, demographic changes leading to larger school-age cohorts have large effect on public finances. Although aggregated statistics may be misleading

in a country as large and diverse as the United States¹⁷, they give a good approximation of the potential strain caused by demographic evolutions on the education of states.

The enrollment in U.S. public schools was up 0.1% in 2007, but actually declined in 22 states and the District of Columbia¹⁸ (NEA, 2009). In 2008, it was up 0.16%. Over the period 1999-2009, the annual percentage change in Fall enrollment varied between 0.1% and 0.9%, but has remained under 0.25% ever since 2006.

The increase in school enrollment has thus followed a slow pace over the 2000s, in stark contrast with the early 1990s when the population attending elementary and secondary schools was increasing at an annual rate of nearly 2%. Given that states have significantly cut back on elementary and secondary education spending (-1% in 2008-09 and -6.2% in 2009-10), it is clear that there has been a transfer of burden from the states to local school districts.

COURT RULINGS

An often forgotten potential cause for fiscal stress is the rulings passed by state and federal courts that increase costs or reduce revenues for states. Prisons overcrowding and mental health issue have traditionally constituted the bulk of decisions. Other

¹⁷ The total U.S. resident population increased by 10.6% between 1997 and 2007, with Nevada experiencing the largest increasing (+45.4%) and Louisiana the largest decrease (-2.9%).

¹⁸ Including New York (-0.5%). The state counted 2,711,603 students enrolled in its public schools in Fall 2008, the third largest population after California and Texas.

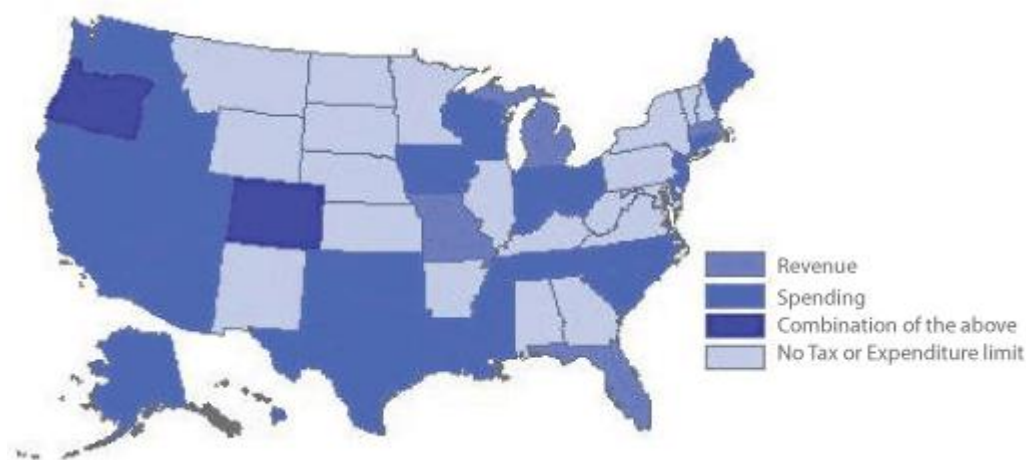
court rulings struck the organization of school finance systems when they were deemed less favorable to students from poor districts or disabled students or required states to provide larger payment to health care providers.

A recent example is the decision offered by the Supreme Court of the United States in the case *Brown v. Plata* (Supreme Court, 2011) which ordered the state of California to reduce its prison population by more than 30,000 inmates as it failed to provide sufficient care to prisoners.

VOTER INITIATIVES

Proposition 13, an amendment to the Constitution of California passed in 1978, spearheaded a certain number of voters initiatives that limited budget flexibility. As of December 2008, 30 states operated under a tax or expenditure limitation (TEL). A majority, 23, had spending limits while 4 had tax limits. Only 3 states implemented both. The evidence supporting that TELs effectively limit the size and spending of state governments as well as improve their efficiency is quite mixed (Gordon, 2008; Waisanen, 2008) and seems to be heavily dependent on the legal specificities proper to each states.

Figure 2.2. State Tax and Expenditure Limits (as of 2008)



Source: National Conference of State Legislatures

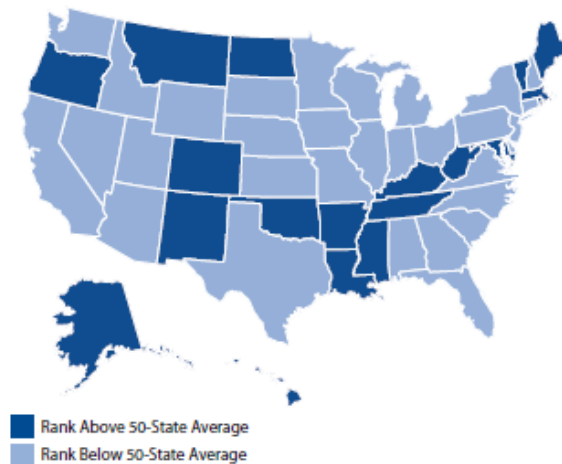
EXCESSIVE SPENDING

The legacy of structural overspending during the boom periods of the business cycle is not shared by every state but has been an acute issue in certain. Moore (1991) and Edwards et al. (2003), following the recessions of the early 1990s and 2000s, have suggested that some states were responsible for their poor fiscal performance during periods of economic stagnation because of the new spending programs they implemented during expansionary times. Even though the sustainability of states fiscal policy is still a heavily debated topic with an unclear terminology (Ward and Dadayan, 2009), a small study by Mitchell (2010) finds a positive relationship between the growth of per capita spending and the size of the budget gap over the period 1987 – 2007. Another study by Stansel and Mitchell (2008) focusing on the 2001 crisis and its

aftermath also found statistical evidence that overspending could translate into increased fiscal stress.

According to data from the National Association of State Budget Officers and controlling for inflation and population growth, the total spending growth rate averaged 29% for the 50 states between FY 2000 and FY 2009. 19 states were above the average, with West Virginia (+152%), Vermont (+98%), Alaska (+86%), Oregon (+65%) and Colorado (+61%) at the top and Florida (-14%), South Carolina (-12%) and Georgia (+1%) at the bottom. Among large states having experienced repeated troubles during previous recessions, only Massachusetts (+43%) had a growth rate higher than the average. New York (+29%) and Pennsylvania (+27%) were close to the average. Spending growth was relatively moderate in New Jersey (+22%), California (+18%), Connecticut (+11%), Michigan (+5%) and Illinois (+2%).

Figure 2.3. Total state spending growth rate (annual average, FY 2000 – FY 2009)



Source: National Conference of State Legislatures

DYSFUNCTIONAL TAX SYSTEMS

The revenue structure of each state differs widely¹⁹, but on average 51.7% of the states' general revenue came from taxes in FY 2008. They consist of income and sales tax, excise taxes and license taxes. They are completed by different charges and fees which represent approximately 10% of revenues. Among these two categories, tuition fees from higher education institutions and revenues from state hospitals are the two largest contributors. The rest consists of fees collected on public services such as transportation, tolls and waste disposal.

Table 2.1. Taxes as a proportion of state and local governments' revenue (FY 2007)

	States	Local Governments
Sales / gross receipts taxes	34%	10%
Personal income taxes	26%	3%
Property taxes	1%	44%
Corporate income taxes	5%	1%
Other taxes	7%	4%
Nontax revenue	26%	38%

Source: U.S. Census Bureau

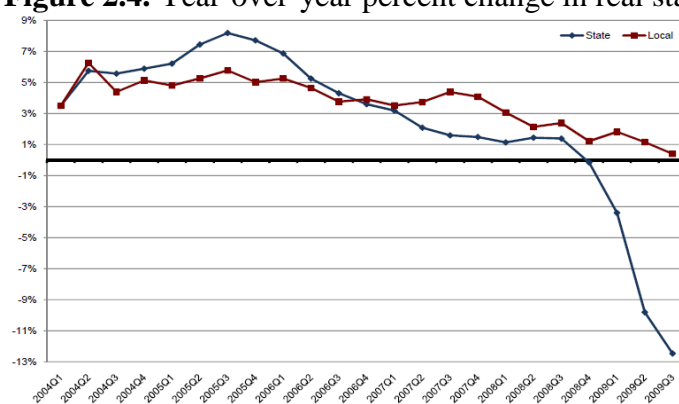
A tax system can be considered to be dysfunctional when it fails to fulfill four conditions: adequacy, stability, breadth and progressivity²⁰.

¹⁹ For instance, the largest item in Alaska's revenue sources is "miscellaneous" (the royalties for oil exploitation) while Mississippi's general revenue is essentially driven by transfers from the federal government. Nevada, because of its large tourism industry, is heavily reliant on the sales tax, hotel taxes and taxes on casino revenue. Total tax revenue in Oregon came mostly (77%) from personal and corporate income taxes.

²⁰ The National Conference of State Legislatures utilizes a more comprehensive framework to judge of the quality and effectiveness of states tax systems. Among the principles it refers to are: reliability, equity, compliance, administration, responsiveness to interstate and international competition, economic neutrality and accountability (NCSL, 2010). We focus here on the two first dimensions.

- Adequacy relates to the ability of a tax system to provide sufficient revenue to fund the state's expenditures. A good proxy to measure the adequacy is the existence of structural budget deficits, i.e. a permanent imbalance between revenues and expenditures. A study by the Brookings Institution found that in the case of the California and the Intermountain West, only Colorado had no structural deficit. In California and Arizona, it amounted to 12% of general fund expenditures (Murray et al., 2009). It was 17% in Nevada.
- Volatility of tax revenues has been a strong cause of increased fiscal stress among states. A study by the Rockefeller Institute of Government presented to the Committee on the Judiciary of the U.S. House of Representatives suggests that overall state tax collections collapsed by 11% in 2009, down to levels not seen since 2000 (Ward, 2010). On the contrary, local governments were relatively shielded from this trend because of the stability of the property tax.

Figure 2.4. Year-over-year percent change in real state taxes and local taxes

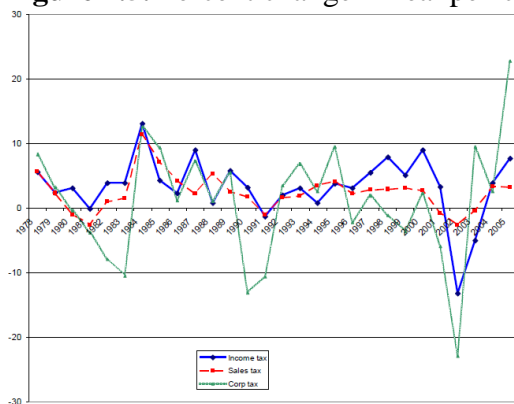


Source: Dadayan and Boyd (2010)

Notes: (1) 4-quarter average of percent change in real tax revenue; (2) No adjustments for legislative changes

The volatility of states tax revenues – defined as the relationship of state tax revenues to the state’s business cycle – during recession is not new. But it has certainly increased with the progressive transformation of the tax system of the “average” state, in particular its heightened reliance on the personal income tax. The income tax rose from representing 24% of total state tax revenues in 1975 to more than 34% today, while the proportion of the corporate income tax has slowly declined from 8% in 1975 to 6% in 2009. Mattoon and McGranahan (2008) found statistical evidence that favoring income taxes as the main revenue source has made certain states²¹ much more sensitive to the business cycle, especially when they are cumulated with a tax on capital gains. But even states with relatively low tax volatility can face fiscal difficulty when the economic environment becomes unfavorable.

Figure 2.5. Percent change in real per-capita state tax revenue



Source: Boyd, 2009

²¹ 10 states have a statistically significant increased cyclical sensitivity: **New York**, Arizona, California, Georgia, Massachusetts, North Carolina, New Jersey, Ohio, Pennsylvania and Virginia.

- The **breadth** of the tax base has three dimensions. First and foremost, it depends on the nature of the different taxes a state enacts. States relying heavily on a single type of tax are more sensitive to economic downturns than states that can rely on alternative tax sources to fund their activities. The second dimension deals with the structure of the economy. As it moved from a durable goods consumption base to a service-oriented base the sales tax has come to cover a shrinking share of total household spending. Taxation of services – except those related to the sale of a tangible personal property – remains rare in most states (Hellerstein et al., 2009). Furthermore, as a society ages more and more of its households derive their revenues from non-taxable (or weakly taxed) sources such as pensions. This implies that the income tax base gets narrower. The last aspect of the breadth of a state’s tax base is politics, with politicians often willing to shrink the tax base to satisfy voters or attract new industries on their territories.
- In modern democracies, the **regressivity** of a tax system is the final component to observe to determine whether or not it is functional²². An analysis of the fairness of state tax systems yields widely different conclusions according to the states under consideration, in particular given the types of tax they collect. If the state income taxes are progressive, property taxes levied by local governments and sales and excise taxes are typically regressive. The Institute on Taxation and Economic Policy found that in FY 2007 “nearly every state

²² Fairness is thus incorporated as a defining element of a well-functioning tax system.

and local tax system takes a much greater share of income from middle- and low-income families than from the wealthy; that is, when all state and local income, sales, excise and property taxes are added up, most state tax systems are *regressive* (Davis et al., 2009). According to this study, the four best performers in the regressivity category were the District of Columbia, Delaware, Vermont and New York.

Figure 2.6. State and local taxes on residents in FY 2007 (% of total income)



Source: Davis et al., 2009

From an empirical point of view, the most comprehensive measure capturing the deterioration of a tax system is certainly its personal income elasticity, i.e. the percentage change in revenue resulting from a 1 percent increase in personal income. Between 1965 and 2007, the long-run elasticity of total state tax revenue for the 50 states and the District of Columbia has been estimated to be 1.17 (Felix, 2008). This means that for each additional dollar in personal income, states have perceived on

average²³ \$1.17 more in tax revenues. The elasticity of tax revenue is dependent on the type of tax under consideration. It has been established that corporate income tax revenues sales tax revenues tend to have an elasticity slightly inferior to the unit (0.92), with the general sales tax closer to one than the sales taxes on alcohol, tobacco and gasoline. The personal income tax, although this is not universal, has a higher elasticity and a higher volatility (Bruce, Fox and Tuttle, 2006).

SENTENCING AND CORRECTIONS POLICIES

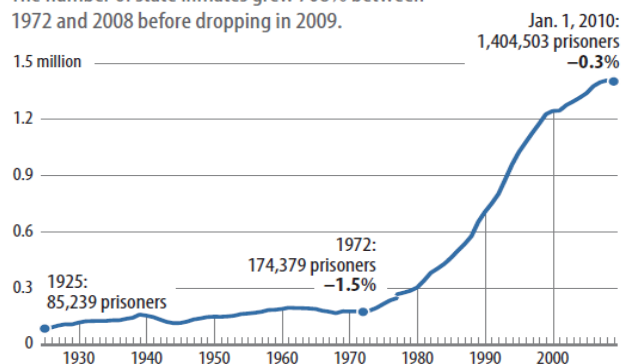
Since 1972 there has been a structural growth in the number of state inmates²⁴ which skyrocketed from 174,379 to 1,404,503 in 2009. Cumulated with prisoners in local jails and federal penitentiaries, it is estimated that approximately 1 in 100 American adult is behind bars. With stiffer and longer sentences passed, corrections costs have steadily climbed over the past 20 years, and now represent nearly 7% of state general fund discretionary dollars, or \$50 billion. In terms of growth as a share of state expenditures, corrections was only topped by Medicaid.

²³ There is substantial variation from state to state. The personal income elasticity of tax revenue in Colorado over that period was actually inferior to one, whereas it is substantially larger than 1.17 in the case of Kansas.

²⁴ Prisons indeed concentrate 88% of the increase in the correctional budget over the past 25 years. The rest of the increase went to probation and parole.

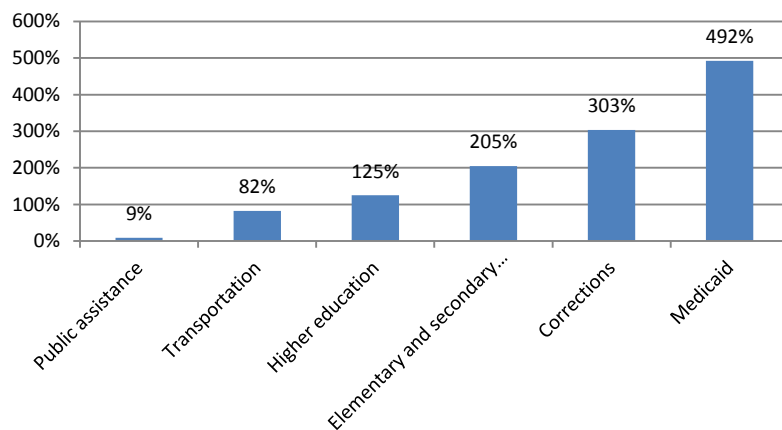
Figure 2.7. Total state prison population

The number of state inmates grew 708% between 1972 and 2008 before dropping in 2009.



Source: Pew, 2010

Figure 2.8. Growth in the principal budget items of state governments (FY 1988 – FY 2008)

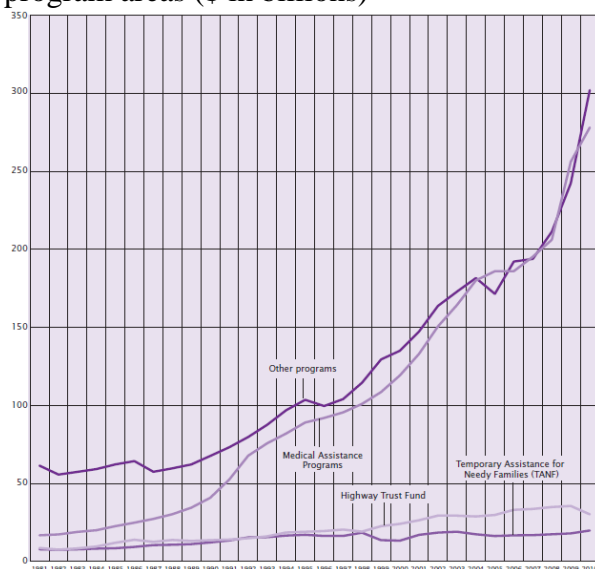


Source: Pew, 2009

FEDERALISM

Through fiscal federalism and the aid it grants, Washington has a strong bearing on the budgets of state and local governments. In fiscal year 2010, grants and other payments from the federal government to state and local governments amounted to more than \$630 billion, up from \$253 billion in FY 1998 (Census Bureau, 2011). The largest area was the Medical Assistance Program, with \$278 billion (44.1%).

Figure 2.9. Federal aid to state and local governments: annual amounts by major program areas (\$ in billions)



Source: Census Bureau, 2011

By agency, Health and Human Services topped the ranking with \$348.2 billion, followed by Education (\$73.2 billion), Transportation (\$63.9 billion) and Agriculture (\$32.8 billion). The number of federal aid programs to the states has also skyrocketed over the past 20 years: they numbered 463 in 1990, against 1,122 in 2010 (Edwards, 2011).

In the dire hours of the recession, federal fiscal relief proved particularly important for states to close their burgeoning budget gaps. Indeed, on the \$787 billion made available by Congress under the American Recovery and Reinvestment Act of 2009 – commonly referred to as the “stimulus package” – \$140 billion directly went to the states. The Center on Budget and Policy Priorities estimated that the package would help states close on average 40% of their budget shortfalls over the three fiscal years

starting in 2009²⁵ (Oliff, Shure and Johnson, 2009). These dollars were primarily used to fund Medicaid (\$87 billion) and education (\$50 billion).

There has been a relative consensus about economists that increased aid from the federal government was a relatively inexpensive way to stabilize the economy. For instance, Zandi (2009) found that among the measures contained in the ARRA, general aid to government had one of the highest multipliers.

Table 2.2. Economic impact of the fiscal stimulus

Spending increases	Multiplier
Extending unemployment insurance benefits	1.61
Temporary federal financing of work-share programs	1.69
Temporary increase in food stamps	1.74
General aid to state governments	1.41
Increased infrastructure spending	1.57
Tax cuts	
Non-refundable lump-sum tax rebate	1.01
Refundable lump-sum tax rebate	1.22
<i>Temporary tax cuts</i>	
Payroll tax holiday	1.29
Across-the-board tax cut	1.02
Accelerated depreciation	0.25
Loss carryback	0.21
Housing tax credit	0.9
<i>Permanent tax cuts</i>	
Extend unemployment insurance benefits	0.51
Make Bush income tax cuts permanent	0.32
Make dividend and capital gains tax cuts permanent	0.37
Cut in corporate tax rate	0.32

Source: Moody's Analytics (2010)

²⁵ New York State reported it would close 31% of its gap.

Since Gerald Ford refused in 1975 that the federal government comes to the rescue of the ailing finances of New York City – an adamant position translated by the tabloid press in a famous cover “Ford to City: Drop Dead”²⁶ – Washington has been more inclined to support state and local governments in times of recession. If Ronald Reagan briefly inversed the trend in 1981, most of the reductions he proposed afterward were blocked by Congress. Given the explosive growth of Medicaid and the uncertain economic context during the presidency of George H. Bush, federal aid soared by \$72 billion between 1989 and 1993. In the early 1990s, states were also eager to transfer costs to the federal government via legal loopholes, the most famous of which was the use of provider-specific taxes and donations as a source of state matching funds (GAO, 1994). In general, however, Washington has played a positive role in the state budget equation.

CONCLUSION

The sources of the current episode of fiscal stress among states are plural, and if we reviewed an important number of them, the list is far from being exhaustive. Moreover, the finances of each state are subject to their own cyclical and structural factors which make any generalization difficult. The violence of the recession certainly explains a good deal of the state fiscal crisis but we have seen that other causes – such as the structural growth of Medicaid or an increased reliance on a more volatile tax base – also played an important role. Several states experienced unsustainable rates of growth of their expenditures and probably would have

²⁶ *The Daily News*, October 30, 1975.

experienced substantial fiscal stress in the coming years even there had been no recession.

2.2 Cutback Management in an Era of Scarcity

The oil shock of 1973, the legacy of overspending of the 1960s as well as the long-lasting stagflation of the 1970s led to the first post-war experiences of fiscal stress for state and local governments. These events caused a large number of states to deviate significantly from an efficient management of their finances, crippling the certitude of the era of “grand expectations”²⁷ that public revenues and expenditures would continue to expand vigorously and continuously. Since the 1970s and the quasi-bankruptcy of New York City, budgetary issues at the state and local levels have been cyclically dominated by resource scarcity, entering an “era of limits” (McTighe, 1979:86) characterized by cutback management. The idea that public agencies would continue to grow incrementally *ad infinitum*, a core concept of public finance, effectively collapsed.

2.2.1 The evolution of cutback management strategies since the 1970s

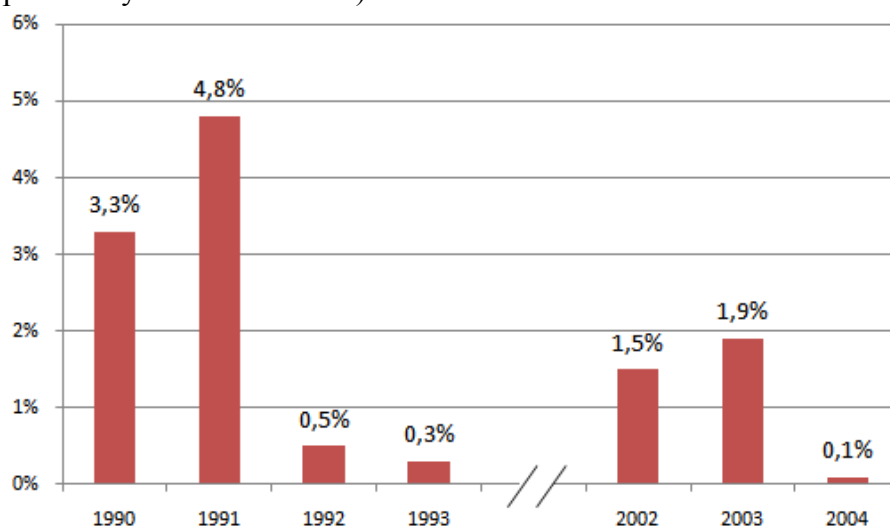
Cutback management, defined by Levine (1979) as the management of “organizational change towards lower levels of resource consumption and organizational activity”,

²⁷ The expression, coined by historian James Patterson (1997), refers to the United States between 1945 and 1974.

took root in public administration when states and local governments started to experience regular episodes of fiscal distress. The nature of cutback management, however, significantly evolved with policy priorities and political necessities. Up until the 2000s, state governments addressed their ailing public finances by both increasing revenues and cutting expenditures, trying to shield education and Medicaid from significant cuts. Borrowing and using up contingency reserves – such as rainy day funds²⁸ – were also utilized to cushion the impact of the crises (Braun et al., 1993). Inefficient budget cuts targeting a percentage reduction of expenditures across-the-board and destabilizing variations in tax rates resulted (Dougherty and Klase, 2009). The burst of the dot-com bubble and the post 9/11 recession marked a shift in policy. Governors and legislatures alike have been increasingly reluctant to increase revenues through taxation (see figure 2.) and have overwhelmingly favored cuts to services to balance their budgets (Maag and Merriman, 2003; Scorsone and Plerhoples, 2010). This is especially true in states that enacted tax caps. Bowling and Burke (2006), paralleling some findings from Poterba (1996), indeed demonstrated that states having tax caps engage in deeper cuts than the states that do not.

²⁸ Rainy day funds are an innovation of the early 1980s.

Figure 2.10. Tax increases during the 1991 and 2001 recessions (percent of the previous year's tax revenue)



Source: Scorsone and Plerhoples (2010)

The widespread use of spending cuts during the last two recessions might also have an additional cause beyond political and social preferences. Rubin and Willoughby (2009) found the steeper and the longer the recession is, the more likely are states to use a broad array of strategies. Because there are only so many tax increases that can be enacted, it is not surprising to find that during episodes of acute economic crises spending cuts are increasingly used as the recession unfolds. On the tax side of this broad array of strategies, policy alternatives usually deals with a change of the tax structure to accommodate losses of revenue caused by the recession or a simple mark up of the tax rate to increase tax collections. Along these states can also seek new nontax sources of revenues, prominent among which is federal aid. Cutting expenditures to match the new level of revenues is also an alternative, as well as borrowing additional funds.

2.2.2 Patterns of cutback management

THE “PHASED-IN-RESPONSES” MODEL AND FISCAL GIMMICKS

An aspect of cutback management broadly discussed in the literature is the pattern – if one exists – through which state and local governments engage in fiscal retrenchment. Klase and Dougherty, in an influential 2008 paper, support the model of “phased-in responses” initially proposed by Levine et al. (1981). According to this model, states engage first in across-the-board cuts to tackle their deficits. When the strategy proves insufficient, they then turn to targeted budget cuts and program eliminations. Practically however, many of the actions taken by state governments are one-time-only measures, which usually span four categories:

- Across-the-board cuts, including laying off employees
- Tapping rainy funds
- Reorganizing programs
- Other methods, such as offering early retirement, delaying expenditures or increasing sin taxes

The use of these one-time-only measures, pejoratively referred to as “fiscal gimmicks”, is quite common, and is the object of fierce political and rhetorical battles between the several offices that share responsibility for the budget²⁹. For instance, the Office of the New York State Comptroller systematically criticized an overuse of fiscal gimmicks by the Legislature and the Governor during recessions.

²⁹ Usually the state legislature, the office of the Governor and the state Comptroller.

Table 2.3. Assessment of the New York State budget by the State Comptroller

Letter from the Comptroller 2003 (p.7)	"This year's budget continued the State's reliance on debt, non-recurring resources and other fiscal gimmicks"
Letter from the Comptroller 2008 (p.7)	"The State's repeated reliance on band-aid solutions, such as budgeting for risky revenues that often do not materialize, nonrecurring resources – know as "one-shots" – and the issuance of debt to parch over single-year budget gaps has created the illusion of a more solid and reliable revenue foundation than actually exists"
Letter from the Comptroller 2009 (p.7)	"Instead of constraining spending to available revenues, the State again used temporary revenue as a short-term solution to the State's budget crisis and did not address the State's long-term structural budget imbalance"
Letter from the Comptroller 2010 (p.7)	"The State continues to be overly reliant on non-recurring, temporary and risky resources to balance its budgets"
Letter from the Comptroller 2011 (p.7)	"The State Fiscal Year 2011-12 Enacted Budget made significant progress in addressing the State's structural deficit primarily through spending reductions and without relying heavily on temporary revenue, one-shots or fiscal gimmicks"

Source: Office of the New York State Comptroller, Comprehensive Annual Financial Report, various years

A TAXONOMY OF STRATEGIES FOR FISCAL ADJUSTMENT

Strategies to carry out short-run and long-run fiscal adjustments have been classified by the National Association of State Budget Officers (NASBO, 2002) in four categories: general, revenues, expenditures and other.

Table 2.4. Strategies to balance the budget

GENERAL	REVENUES	EXPENDITURES	OTHER
Across-the-board cuts	Close corporate income and individual income tax loopholes	Appropriation controls	Medicaid cost containment measures
Targeted cuts	Corporate tax	State employee	Develop a baseline

	surcharge	retirement and benefits adjustments	
Budget stabilization fund / other reserve funds or borrowing against them	Change state tax filings	Delay program expansions	Revenue forecasting
Tobacco settlement funds	Delay tax cuts	Use of technology	Error analysis
Revenue transfers	Debt finance	Alter end of year spending practices	
Layoffs, furloughs, early retirement, and hiring and salary freezes	Add income tax bracket	Use of one-time revenues	
Travel freezes	Create state lotteries and gaming	Bond sells	
Program streamlining and reorganization	Creative tax adjustments	Defer or cut reimbursements	
Cut local government aid	Amnesty programs	Suspend tax credits and deductions	
Privatization and contracting -out	Enhance penalties	Close parks	
Tax and fee increases	Enhance standards for exemptions	Freeze COLA for programs and employees	
Freeze state spending	Loosen legislation on local Government	Delay payments	
Tax increase referenda	Divert a portion of the sales tax	Defer tax refunds	
Spending controls	Sell or sale-leaseback	Keep vacancies unfilled	
	Bond refinancing	Review contracts	
	Speedup tax collections	Cut, reducing, or suspending K-12 and university programs	
	Step up donation solicitations for colleges and universities	Prolong in-state-tuition qualifications	
	Use multi-year forecasting	Providing fiscal incentives to save	
		Accelerate capital projects	
		Stimulate tourism	
		Reduce allotments	

Suspend training
Eliminate state-subsidies
Material cutbacks
Change funding formulas

ARE STATE FISCAL POLICIES PRO-CYCLICAL?

The expansion and success of the Welfare state had profound consequences for state public finances. Indeed, Medicaid coverage and demand for welfare subsidies – in particular unemployment aid – boom during recessions, whereas forecasted growth in revenues trail significantly financing needs. Due to these automatic stabilizers³⁰, a mechanical weakening of the states balance sheet ensues. The pattern is aggravated by the still dominant belief during periods of boom that state revenues will continuously improved. On that account, legislatures pursue aggressively policies of budget and services expansion when the economy experiences economic growth, even though a rising proportion of revenues must be channeled to fixed expenditures, first among which are health care programs. The consequence is a pro-cyclical fiscal policy: states slash spending when their economies' needs for government demand is the greatest while they increase tax rates on a shrinking and struggling tax base (McGranahan, 2002).

³⁰ Automatic stabilizers are usually defined in the literature as the elements of fiscal policy resulting from non-discretionary government action which contribute to mitigate the fluctuations of aggregate output (Eaton and Rosen, 1980).

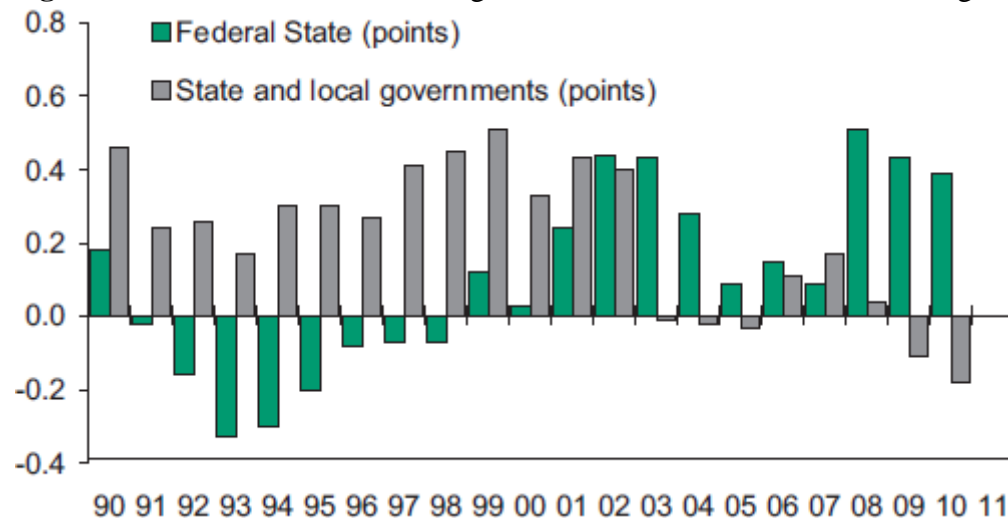
The pro-cyclicality of the fiscal policies of states governments is also an artifact of the strict balanced budget rules they came to enact. If the federal government is indeed authorized to run deficits to help stabilizing demand and output – a legal feature which enables it to play a counter-cyclical role during recessions – this is not the case of most states³¹. This is nowhere more apparent than in the comparison between the policy-mixes adopted by the federal government and by the state governments. While Washington entered the recession with a clear focus on counter-cyclical actions (ARRA, TARP, temporary cuts on payroll taxes, extension of the Bush tax cuts, extension of unemployment benefits), state legislatures slashed their payrolls, cut programs and raised taxes.

Moreover, state governments tend to formulate unbalanced responses to changes in their economic and fiscal environment. Poterba (1994) finds that states have vigorous reactions to unexpected deficits but are unresponsive to unexpected surpluses. Public agencies as declining organizations must therefore answer tough questions when deciding whether or not they should resist or embrace cuts, the magnitude of the cuts, their repartition and the tradeoff that exists between efficiency and equity. These questions form the core of cutback management as an academic discipline (Levine, 1979). Bartle (1996) offers an overview of its application to the case of cities in New York State that have faced important shortfalls in revenues.

³¹ Vermont is the only exception. The strictness of the balanced budget rules vary by states.

In general, the pro-cyclicality of states' fiscal policies has had a negative impact on aggregate demand. The mechanism plays through two channels: (i) a direct channel when states slash their payrolls, reduce benefits and raise taxes and (ii) an indirect channel when they cut back on expenditures that themselves represent a demand for local businesses. Excluding the indirect effects, the Bureau of Economic Analysis found that the fiscal policies of state and local governments took 0.1 point off GDP growth in 2009, and 0.2 point in 2010 and the outlook remained negative for 2011 and 2012.

Figure 2.11. Contributions to GDP growth of the federal and non-federal governments



Source: Lucas, 2011

Even more interesting in the case of this recession, state and local governments continued to weight down on GDP growth even after the recovery started (Canally, 2011). Over the deepest recessions that struck the U.S. economy since the first oil shock, this is the first time that state and local governments contributed negatively to the expansion of the GDP.

Table 2.5. Contribution to GDP growth over the first seven quarters of recovery (in percentage points of GDP growth)

	Recovery from 2007 – 2009 recession	Recovery from 2001 recession	Recovery from 1990 – 1991 recession	Recovery from 1981 – 1982 recession	Recovery from 1973 – 1975 recession
Consumer spending	11.0	13.3	15.4	24.7	18.9
Housing	-0.3	3.0	3.0	7.3	6.2
State & Local government spending	-1.5	0.8	1.4	2.2	0.2

Source: Canally, 2011

Note: longest episodes of recession according to the NBER

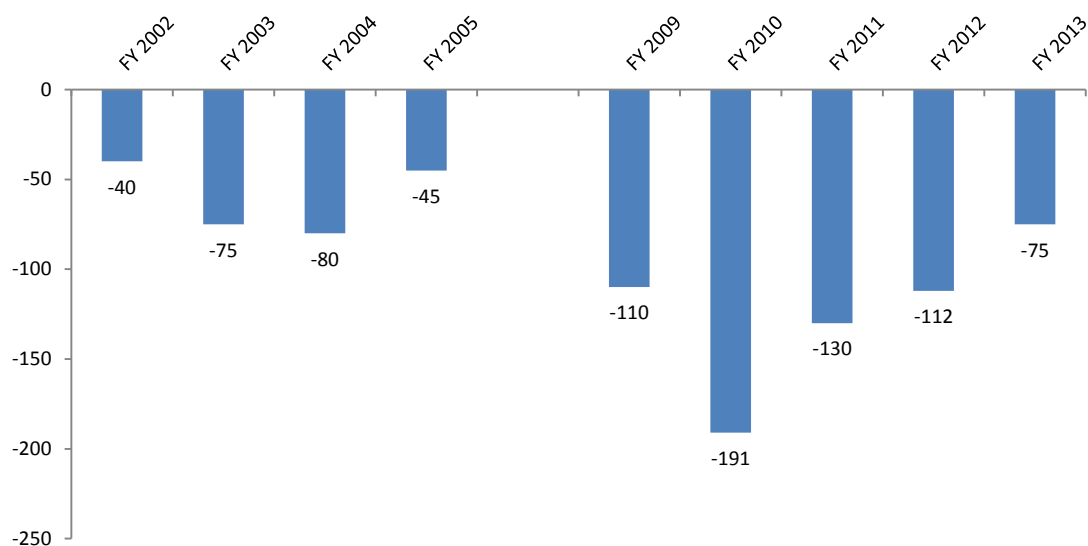
2.3 The States in the Financial and Economic Crisis: Conditions and Policies

2.3.1 General indicators of the deficit

In fiscal 2010 alone, states had to resolve their largest budget gap ever, \$192 billion. This is nearly as much as the budget shortfalls experienced by states in fiscal 2002, 2003 and 2004 combined (\$195 billion). Overall, NASBO (2010, 2011) estimated that states will face cumulated budget gaps of \$296.6 billion between FY 2009 and FY 2012, with nearly \$230 billion realized up to FY 2011. Intervention by the federal government through the American Recovery and Reinvestment Act of 2009 (ARRA), which attributed \$87 billion in Medicaid funds and \$48 billion in education funds, certainly helped bridge the gap, but the program waned down in FY 2011. \$59 billion were transferred to state under this program in FY 2011, an amount that will fall to \$6 billion in 2012. Without this additional help, it is clear that public finances at the state

level will take time to recover. Furthermore, the full effect of the economic crisis and of the dereliction of the real estate market on local finances – which rely heavily on property tax – remain to be seen, because the property tax assessment cycles usually take several years and the effect on sales tax is lagged (Hoene and Pagano, 2009).

Figure 2.12. Total state budget shortfall (\$ in billions)



Source: Center on Budget and Policy Priorities

Note: Data for FY 2012 are preliminary

The deterioration of the states' fiscal position is clearly illustrated by the unprecedented two year decline in aggregated general fund³² spending for FY 2009 and FY 2010, from \$687.3 billion in FY 2008 to \$657.9 billion in FY 2009 and \$612.9 billion in FY 2010. Revenues from sales, personal income and corporate income – which make up to 80% of the general fund revenues – also collapsed by nearly 12% in FY 2009 and remained significantly lower than in FY 2008 in both FY 2010 and 2011.

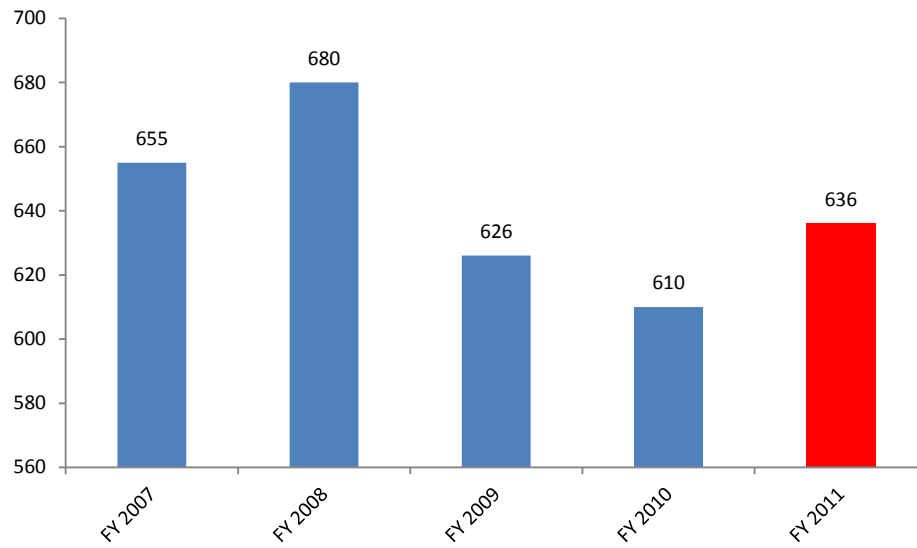
³² General funds, which represented 42.5% of states funding sources in fiscal 2009, is the predominant fund for financing operations. Revenues are drawn from taxes.

To deal with the strain, legislatures increased taxes and fees by \$23.9 billion in FY 2010. Revenue efforts however faded markedly in FY 2011, with less than \$3.1 billion in taxes and fees increases proposed by governors in their budgets. The weakness in revenues along with the expanding demand for state services, in particular social assistance and Medicaid, forced 43 states into implementing mid-year budget cuts in FY 2009, amounting to \$31.3 billion. The trend continued over FY 2010, with 40 states cutting approximately \$22 billion from their budgets during the fiscal year. The cuts were far larger than those realized during the last economic downturn, in 2001-02, when they amounted to \$14 billion and \$12 billion respectively. Gubernatorial spending cuts were the privileged method to close mid-year budget gaps (Scorsone and Plerhoples, 2010).

Manifestation of fiscal stress in the states general funds manifested as early as fiscal 2007³³, when the \$18.2 billion surplus accumulated by states over the year melted into a \$1.9 billion deficit. Fiscal balance in FY 2006 was actually even stronger, as stabilization funds totaled \$22.4 billion, and the fiscal position of the states in early 2008 remained solid. Once again accounting for contingency funds, the general fund remained positive in fiscal 2008. From late 2008 onward, the situation became more and more precarious. With rising unemployment, free-falling industrial activities, deleveraging across economic sectors and contracting consumption, revenues for the general fund collapsed significantly.

³³ The recession officially started in December 2007 according to the National Bureau of Economic Research.

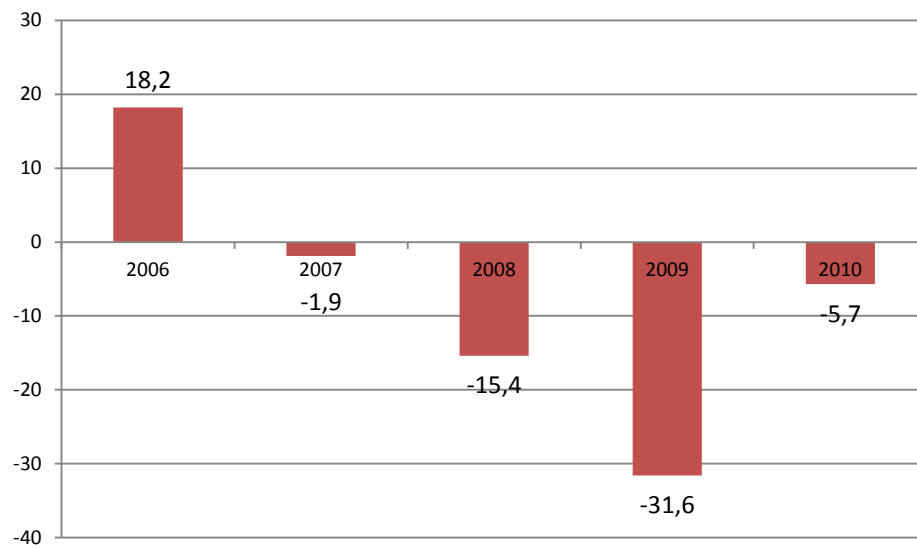
Figure 2.13. General fund revenue (\$ in billions)



Source: NASBO

Note: FY2010 is preliminary actual and FY2011 is enacted

Figure 2.14. General fund balance (\$ in billions)



Source: NASBO

2.3.2 A better indicator of fiscal stress: the year-end total balance level

Deficits themselves are however far from being a reliable indicator of fiscal stress as almost all states are constitutionally required to balance their budgets. The statistic preferred by the National Association of State Budget Officers is the states' year-end balances and how they fare with respect to the recommended threshold of 5% of general revenues³⁴. Balance levels are indeed a more accurate measure of fiscal stress because they essentially capture the fiscal ability of a state to mitigate the impact of an economic downturn on its services and programs. As such, total balances include both ending balances and extraordinary funds that are available to the state to respond to unforeseen circumstances (the so-called rainy day funds)³⁵. Total balance levels are most commonly expressed as a percentage of general fund expenditures, to capture the size of the fiscal cushion on which states can rely to meet their public service obligations.

The quality of this measure is clear when taking the example of the 2001 recession³⁶. NASBO relates that in fiscal 2000, states had accumulated balances reaching a considerable 10.4% of expenditures. By 2003, this bounty had shrunk to 3.2%. The states performed even better during the 2000s. In FY 2006, total balances represented

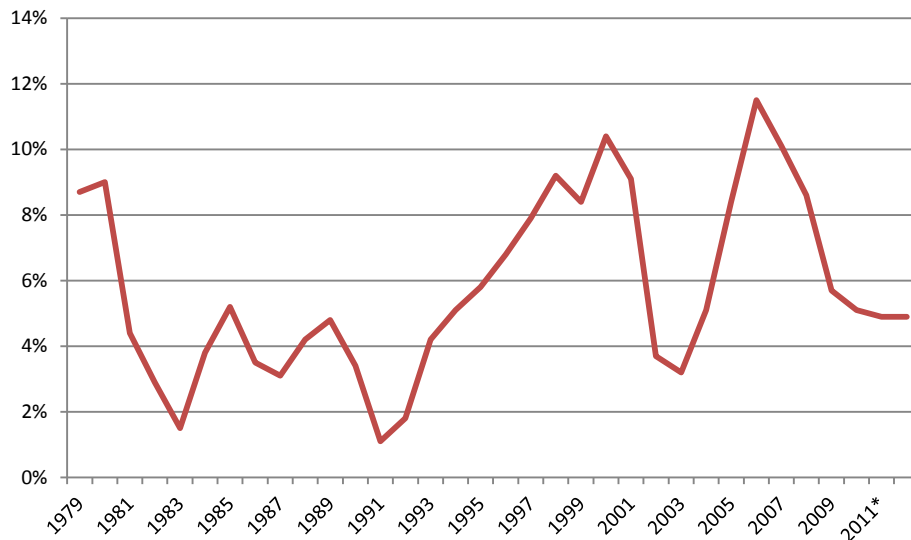
³⁴ The recommendation aims at insuring against inaccurate revenue forecasting and at guaranteeing the state's ability to face emergency situations (for instance natural or human-caused catastrophes) or possible changes in federal legislation.

³⁵ In 2011, 48 states had at least one such fund.

³⁶ A limit of this indicator is that a small number of states can have a disproportionate impact on the national average. Also, the methodology used by each state to report to NASBO is somewhat different.

11.6% of general fund expenditures. The subprime crisis and the following recession substantially altered the picture.

Figure 2.12. Total year-end balances (percentage of expenditures)



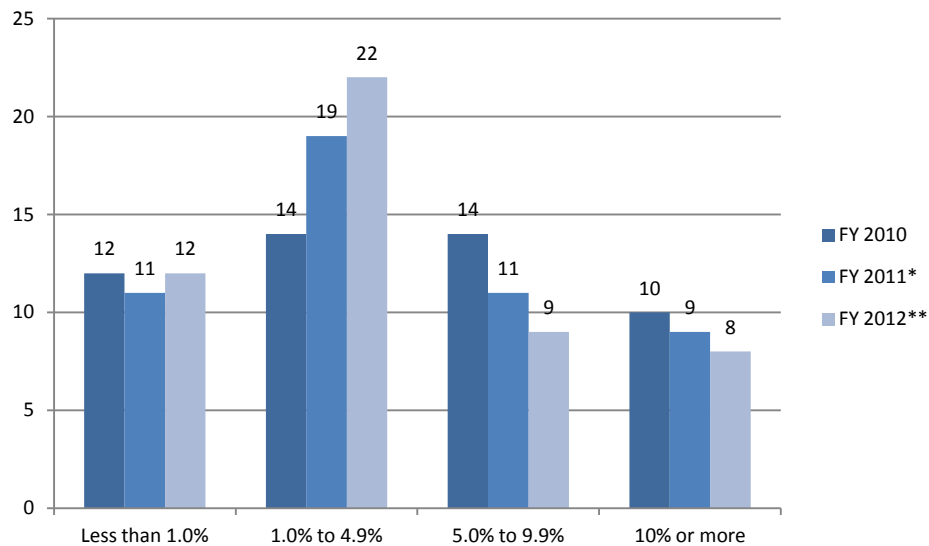
Source: NASBO

The aggregated balance level for FY 2011, at 4.9% of expenditures, although seemingly reassuring, is somewhat of a *trompe l'oeil* as two states alone, Texas and Alaska, made up 48.3% of the total \$31.9 billion³⁷. When removed, the balance levels fall at 2.7%, very close to the dire situation of FY 1991 and far below the recommended 5%. At a more disaggregated level, 11 states had balances inferior to 1% in fiscal 2011. 19 states had balances ranging between 1% and 5%. NASBO estimated that the balance levels would stabilize at a very similar level in FY 2012. It is expected that 12 states will have balances inferior to 1% in fiscal 2012, and 22 states forecasted balances between 1% and 5%. These statistics are particularly important in

³⁷ With \$10.4 billion, Alaska represented a little bit less than a third of the total balance.

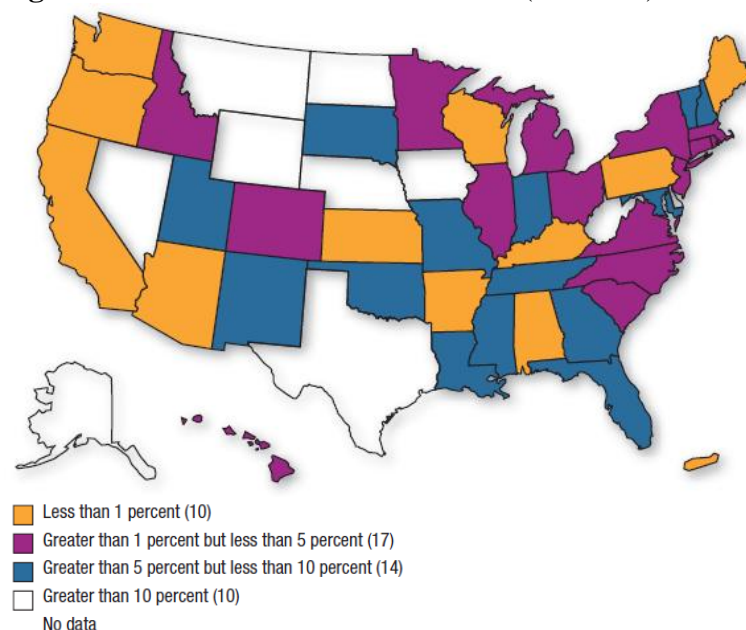
view of our dissertation, which deals with mid-year budget cuts. Indeed, the lower the balance the more difficult it becomes for states to tackle unanticipated budget gaps occurring during the fiscal year. With so many states under the 5% threshold, there is a clear risk of a multiplication of mid-year fiscal adjustments. Moreover, even though the balances remained positive at the height of the crisis, the fact that revenue revival usually trails the national economic recovery implies that legislatures and governors are reluctant to tap rainy day funds to absorb part of the recessionary shock, darkening the picture a little more.

Figure 2.16. Number of states by total year-end balances (as a percentage of expenditures)



Source: NASBO

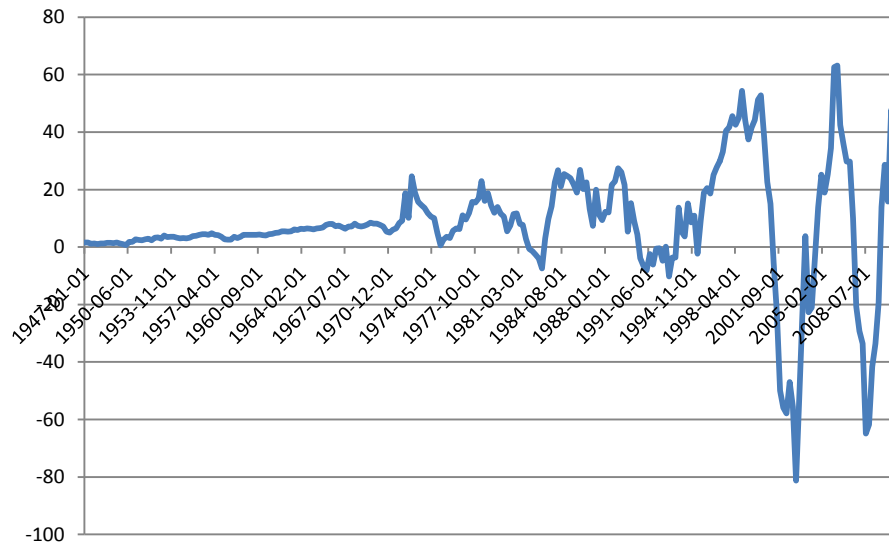
Figure 2.17. Total State Balance Levels (FY 2010)



Source: NASBO

This does not necessarily reflect a lack of preparation, as contingency funds have significantly grown since their inception in the 1980s. State and local government savings started to increase rapidly with the first acute and generalized fiscal crisis in the 1970s. Since the 1990s, the magnitude of savings and deficits has been multiplied several times over, while swings have been increasingly correlated with booms and busts.

Figure 2.18. Net State and Local Government Saving (\$ in billions, quarterly, seasonally adjusted annual rate)



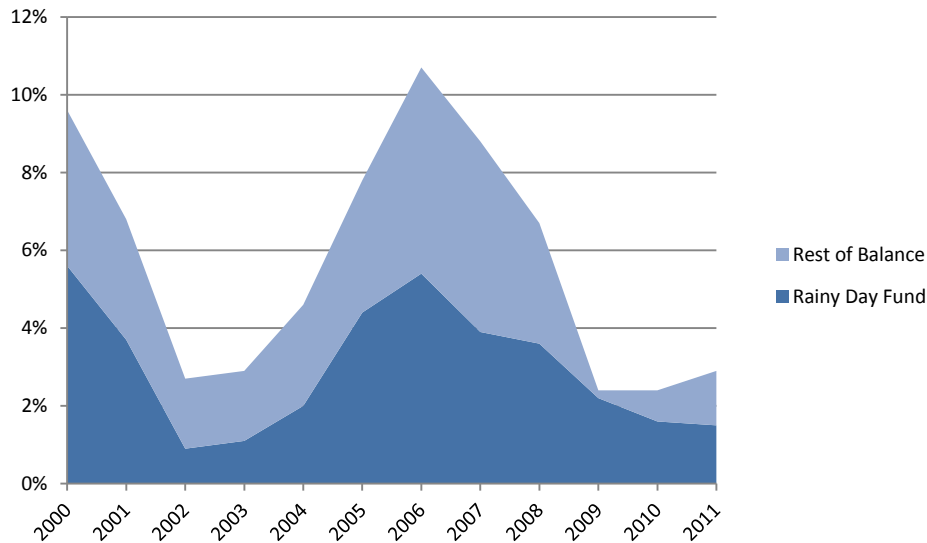
Source: Economic Research Division, Federal Reserve Bank of St. Louis

Curiously, increased level of savings in the form of contingency funds – funds that are parsimoniously used – may have contributed to disqualify tax hikes. Politically risky, tax increases indeed do not appear necessary as long as the states still have funds available in its rainy-day reserve. What is certain is that since their inception, rainy day funds have come to represent a significant proportion of the year-end balances of most states, and as such constitute a strategic tool to manage the business cycle. However, a 5% end-year balance appears to be quite modest in comparison of the fiscal challenges posed by certain recessions. Several institutions argued that a 15% or higher benchmark should be recommended³⁸ (Navin and Navin, 1997; Berube and Lav, 1999; GFOA, 2002), although it should be noted that the optimal size of budget stabilization funds is heavily dependent on the peculiarities of each state (Joyce,

³⁸ That is, a balance capable of financing 2 months of general fund expenditures.

2001). But even at 15%, the rainy day fund balance (\$85 billion) would have been dwarfed by the size of the budget shortfalls faced by states (\$425 billion).

Figure 2.19. State rainy day funds and end-year balances (as a percent of expenditures)



Source: NASBO, 2011

Note: Excluding Alaska and Texas.

2.3.3 Tax increases versus spending cuts

It has been established in the introduction that this dissertation does not take part in the academic and political debate raging about the respective merits and weaknesses of budget cuts versus tax increases. The question, however, merits to be addressed briefly. The argument defended by Keynesian economists is that slashing spending has a depressive effect on the economy because it deprives agents – civil servants, contractors, local governments, non-profit organizations – from much needed revenue

and thus contributes to lower even more the level of aggregate consumption. On the contrary, increasing taxes on high-income brackets has a fairly limited effect on the economy, as the additional income taxed would have been saved nowadays. Except for rare exceptions, it seems that empirical evidences support this view³⁹.

The economic impacts of state tax increases are still however much debated among economists, no matter how important they may be to balance budgets. Brown (1956) argues that the state governments raised taxes so much during the Great Depression in a desperate attempt to jam the vicious circle of falling revenues that they undercut the fiscal stimulus created by the federal government and may have contributed to extend the economic slump of the Thirties.

The question is of interest to us because by using a social accounting matrix framework we make the implicit assumption that the spending multiplier of state governments is positive, i.e. that slashing expenditures would lead to a contraction in the aggregate level of output. Thus, SAM clearly refutes the theory according to which contractions can be expansionary⁴⁰. We will come back to this issue in Chapter IV.

³⁹ For a summary of the debate, see The Economist (2011).

⁴⁰ It is all the more evident that SAM is a static framework, and therefore cannot take into account the anticipations agents formulate about the future state of the economy.

2.3.4 State policies in the crisis

EXPENDITURE POLICIES

Increased fiscal stress caused active spending management

State expenditure levels have been negatively affected by the loss of Recovery Act funds and by lower than expected tax collections. Consequently, 42 states and Puerto Rico reported budget gaps amounting \$73.1 billion in FY 2009. Gaps increased to \$107.8 billion in FY 2010 and 32 states reported \$62.3 billion in budget gaps for fiscal 2011. Because 49 states are constitutionally required to balance their budgets, losses in revenues must be compensated by an equivalent reduction in spending. In fiscal 2010, 36 states used targeted cuts and 28 states across-the-board cuts. Comparatively, only 19 states tapped into their rainy day funds, illustrating the perception in capitals throughout the country that the crisis would extend well into FY 2011 and 2012. Figures were similar for FY 2011, with 35 state governors proposing targeted cuts and 19 across-the-board cuts. 15 governors proposed to use rainy-day funds.

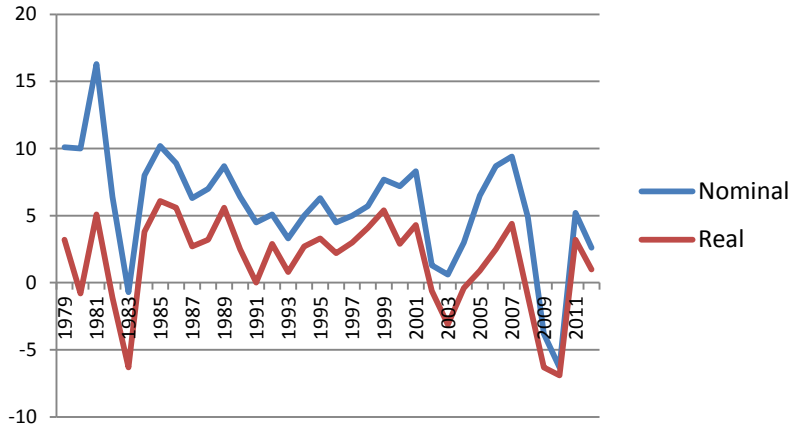
Budget cuts and rainy-day funds are not the only ways for state governments to navigate the difficulties of the crisis. In FY 2010, 26 states employed layoffs and 22 instituted furlough programs to tackle burgeoning deficits. These policies were pursued by 19 and 13 states respectively in FY 2011. The implementation of these pro-cyclical policies has been at the heart of numerous public debates in the United States, and came back at the forefront of the media with the poor performance of the U.S. job market in May and June 2011 (BLS, 2011). Indeed, if the private sector

added 57,000 jobs in May, public employment continued spiraling downward for the eighth consecutive month, especially in state and local governments.

The active management of fiscal policies in the states is clearly illustrated by the change in the growth rate of spending from the general fund. At the peak of the boom in fiscal 2007, expenditures from the general fund grew by 8.5% and 4.2% in FY 2008. Following the Lehman Shock, spending contracted by 3.3% in fiscal 2009. This is in line with the GDP percent change based on chained 2005 dollars for the entire country, at -3.5%, but significantly higher than the contraction recorded in fiscal 1991 (-0.1%). On the other hand, the adjustment has been less brutal than in FY 1983, when real general fund budget decreased by 6.3%. The lag reaction in the case of the 2007 recession seems however to have been magnified, as general fund spending contracted by 5.9% in fiscal 2010. The exceptional character of the early 1980s and 2007 recessions is visible on figure . Moreover, all seven categories⁴¹ of the general fund were negatively affected except for transportation in 2010.

⁴¹ Elementary & secondary education, higher education, public assistance, Medicaid, corrections, transportation and all other expenditures.

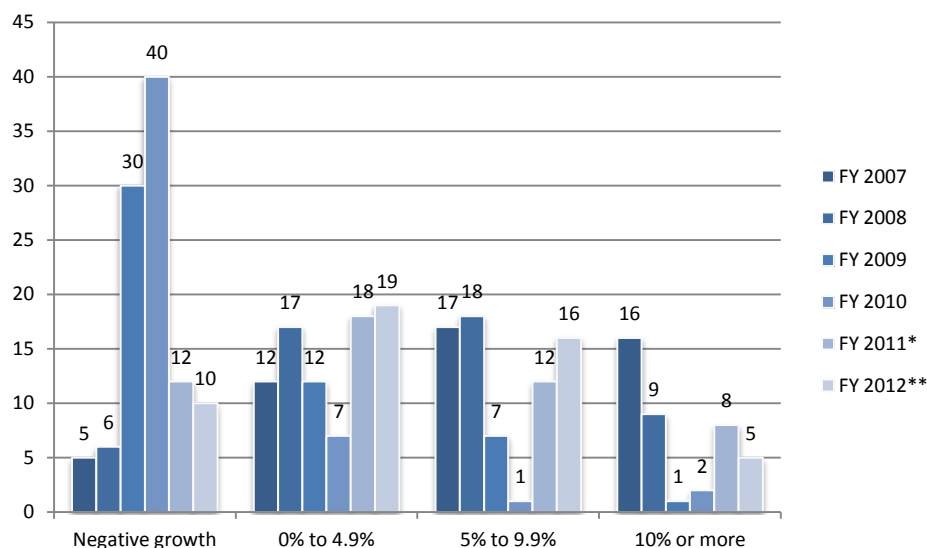
Figure 2.20. Annual percentage budget change, FY 1979-2012



Source: NASBO

State general fund spending trended upward after the drought of 2009 and 2010, with \$651.5 billion spent over fiscal 2011 and \$668.6 billion expected for FY 2012. This is however still far from the level reached in fiscal 2008 where states' general fund spending amounted to \$685.7 billion. At a more disaggregated level, 40 states proposed an increase in general fund spending in FY 2012, even though 29 will still have spending levels below those of fiscal 2008. In fiscal 2011, 20 states recorded general fund spending increasing by more than 5%, while 18 grew by less than 5%. 12 states were still fighting an uphill battle and had general fund spending below fiscal 2010 levels. The picture has thus improved considerably compared with the intense fiscal stress of fiscal 2009 and 2010. Indeed, only 10 states estimated general fund spending growth for FY 2010. This was even worse than for fiscal 2009, where twice as many states increased their spending.

Figure 2.21. Repartition of states by change in general fund spending (FY 2007-2012)



Source: NASBO

* Estimated

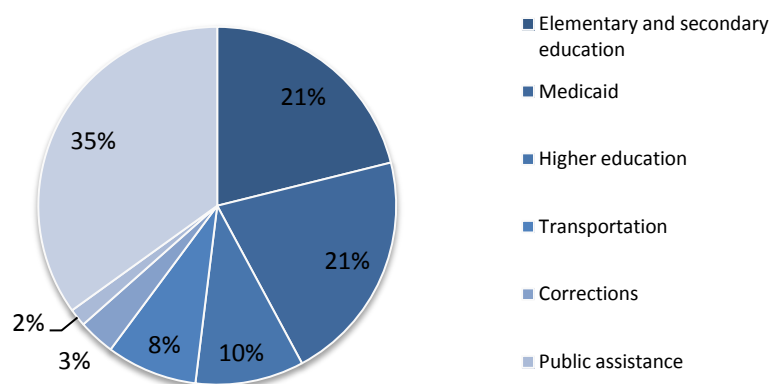
** Recommended

Major spending areas affected

Having established the sources of the fiscal crisis and having put some general statistics on the budgetary environment of the states since the recession of 2007, we can now turn our attention to a more disaggregated picture of the states' fiscal policies. As will be seen clearly in the following paragraphs, states have cut more deeply in their budgets than might have appeared at first hand. Indeed, the federal government helped state legislatures to withstand a considerable amount of pressure, and only by dividing budget contributions by origin can we obtain a better understanding of the delicate situation states are in since 2007. This is why we start this section with what we believe to be the best indicator of fiscal hardship available: the evolution of the states payroll, which clearly illustrates the impact of the economic crisis on state policies across the country.

The structure of state general funds is such that budget cuts must be implemented in a relatively limited number of programs. The bulk of total state spending in FY 2009 was represented by elementary and secondary education, followed by Medicaid and higher education. A significant chunk of spending is also gathered in the “all other expenditures” account⁴². Elementary and secondary education gathered 35.1% of all spending in fiscal 2009, Medicaid 16.2%, higher education 11.1%, corrections 7.2%, transportation 0.7%, public assistance 1.9% and all other expenditures 27.8%.

Figure 2.19. States spending by program (FY 2009)



Source: NASBO

STATE EMPLOYMENT

As illustrated by the grim numbers from the Bureau of Labor Statistics we previously quoted, states have reduced employment to tackle their deficits. It is however difficult

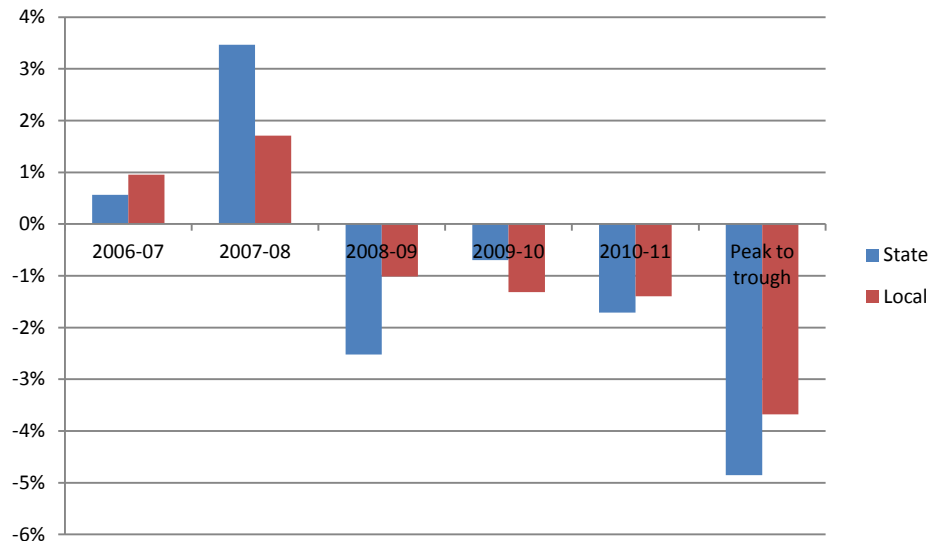
⁴² All other expenditures in states includes the Children’s Health Insurance Program (CHIP), institutional and community care for the mentally ill and developmentally disabled, public health programs, employer contributions to pensions and health benefits (only partially taken into account in the case of New York State), economic development, environmental projects, state police, parks and recreation, housing, and general aid to local governments

to analyze the magnitude of the cuts announced by state and local governments because they usually concern authorized general fund positions, which can be vacant. States can also use accounting techniques to decrease artificially their payrolls by shifting employees from general fund positions to positions financed by fees and charges.

The reduction in state employment, although severe, may thus have been exaggerated in the media. Data from the Bureau of Labor Statistics suggest that state employment reached a peak in October 2008 before continuously falling up until today. States had 5.316 million employees at this time, a number that fell 5.058 million in October 2011 (-200,000 employees)⁴³. In magnitude, losses were heavier in local governments, which employment fell from 14.648 million in October 2008 to 14.109 in October 2011 (-539,000 employees). These numbers appear historically high: in the wake of the 1991 recession, states shed a total of 19,000 workers. Moreover, public employment at this level of government only contracted for a 3-month period.

⁴³ In comparison, a total of 190,000 jobs disappeared in France in 2009.

Figure 2.23. Change in employees on state and local governments payrolls (seasonally adjusted)



Source: Bureau of Labor Statistics, The Employment Situation (various years)

MEDICAID

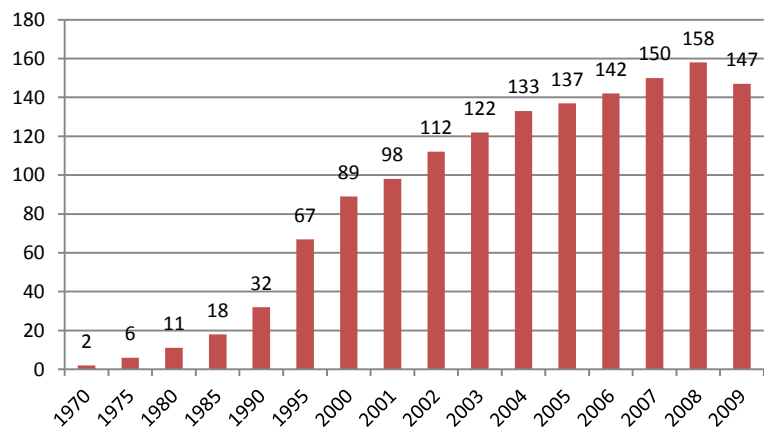
A particular source of strain on state budgets is the Medicaid program, which exponential growth has been difficult to contain even before the crisis. The program, offering comprehensive and long-term medical care for more than 60 million low-income individuals in 2011, has been at the heart of states fiscal policy ever since the 1980s and continued expanding at a rapid pace in the 2000s. As a share of state spending, Medicaid surpassed higher education as the second largest program in fiscal 1990, before taking the top spot from elementary and secondary education in fiscal 2003⁴⁴. The expansion of Medicaid can be attributed to several factors, prominent among which are:

- Booming health care costs;

⁴⁴ There have been changes since 2003: in fiscal 2009, elementary and secondary education became the largest component again, a place it lost in fiscal 2010.

- The growth in the number of Medicaid recipients, propelled by the economic downturn and successive health care reforms extending the benefits of the program to new categories (for instance, the Affordable Care Act of March 2010);
- Increased use of services by recipients and above inflation growth in provider payment;
- Higher premium payments for Medicare.

Figure 2.21. State Medicaid spending (\$ in billions)

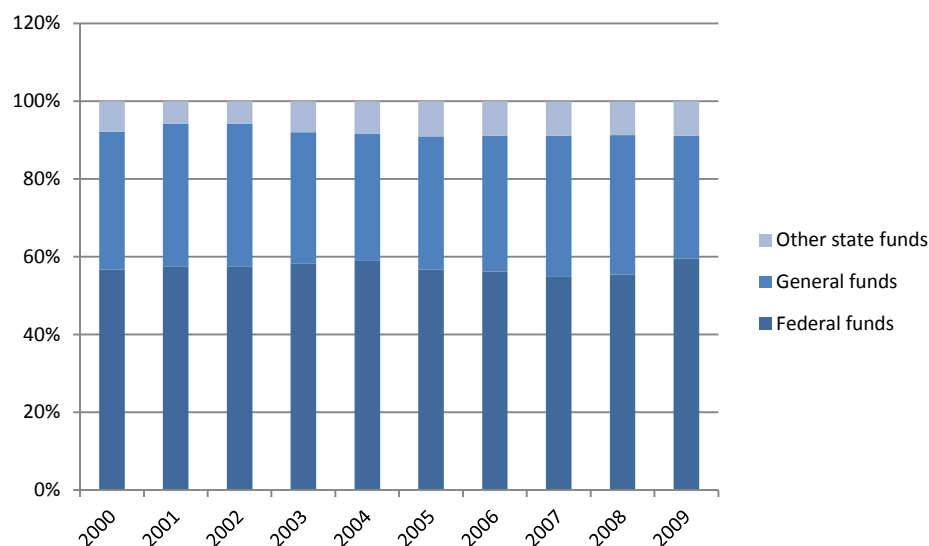


Source: Congressional Budget Office

Due to the recession and its effects on unemployment and income, enrollment for health care coverage boomed by 6% in fiscal 2009, by 8.5% in 2010 and by 6.1% in 2011. Projections anticipate that Medicaid enrollment would increase by 21% over the period 2009-11. Consequently, spending grew by 7.8%, 6.6% and 10.5% in fiscal 2008, 2009 and 2011 respectively. It is difficult to fathom how such an explosive growth could have been accommodated by states in this era of fiscal restriction if one does not factor in the federal government. In fiscal 2008, 42.6% of the federal funds

perceived by the states went to Medicaid. While state funds contracted by 3% and 1% in fiscal 2008 and 2009, federal funds boomed by 16.6% and 14.4% respectively. It is interesting to note that these declines in state spending were a first in the history of the Medicaid program.

Figure 2.22. State expenditures for Medicaid by fund source



Source: NASBO

The boost in Medicaid spending was essentially attributable to the temporary increase in the Federal Medicaid Assistance Percentage under the American Recovery and Reinvestment Act of 2009. However, the expiration of the Recovery Act led to much speculation in policy circles⁴⁵ about the ability of states to cope with the decline in federal support. In total, it has been estimated that the improved FMAP delivered approximately \$103.1 billion to states over the period October 2008 – June 2011.

⁴⁵ In their proposed budgets for FY 2011, certain governors assumed an extension of the funding, while others did not.

Support from the federal government did not prevent states from rolling in new cost containment measures, with reducing provider payments the most popular strategy (39 states in 2010 compared with 33 states in 2009). Other measures include limiting prescription drugs (13 states), delaying expansions (10 states), expanding managed care (9 states) and limiting benefits (9 states). With the recovery of state public finances even slower than the already anemic overall economic growth, limiting benefits and even eliminating benefits altogether have become widespread (20 and 14 states in FY 2010 and 2011 respectively), illustrating the difficulty for governments to find other areas of saving. As the leeway gets narrower and narrower, 17 states decided on raising provider taxes or fees in fiscal 2010, with 5 states completing the move by raising tobacco taxes. On the credit side of their balance sheets, states benefited from the phasing down of contribution to the Medicare Part D clawback payments, a program initiated in early 2006.

To conclude, if the size of the Medicaid program and its growth have been a source of fiscal stress for states, it is without measure with what could be imagined just looking at the raw figures. The burden of Medicaid spending has indeed been essentially shouldered by the federal government, although the situation should deteriorate significantly at the expiration of the American Recovery and Reinvestment Act.

WELFARE

Unsurprisingly, public assistance expenditures – essentially the Temporary Assistance for Needy Families (TANF) program – increased markedly during the economic

downturn, as the number of recipients grew and benefits level and eligibility were increased. The pattern of increase was very similar to the one of the Medicaid program. Spending from state governments decreased significantly between fiscal 2008 and 2010 (+0% and -7.4%), while federal funds jumped by 10.6% from FY 2008 to 2009 alone (+14.1% in fiscal 2010)⁴⁶. This however fail to take into account the transformation of public assistance in the 2000s, which progressively shifted away from cash benefits to other type of services, in particular childcare, training and education, transportation, substance abuse and domestic violence.

Federal funding was essentially provided by the American Recovery and Reinvestment Act through an emergency fund for TANF. As a result, the federal government accounted indirectly for 51% of total state expenditures on public assistance in fiscal 2009, a proportion that rose to 56.1% in 2010.

National averages mask tremendous changes according to regions and states. New England and the Southeast region witnessed a rapid growth of their expenditures on public assistance (+9.7% and +8.9% respectively in FY 2009) while they decreased significantly in the Great Lakes and the Rocky Mountains (-9% and -2.7% respectively). The direct contribution of states collapsed in every region except for Mid-Atlantic and the Plains. This decrease was particularly important in the Great Lakes (-37.1%) and the Southwest (-31.5%). On the other hand, the federal

⁴⁶ These data are on a cash basis. The total cost of TANF for the states is actually higher when accounting for noncash services, as the case of Michigan clearly illustrates. It was indeed estimated that the state spent \$389.2 million in fiscal 2008 on child development and care expenditures.

government increased its support to every region, with New England (+64.2%) leading the pack.

Other cash assistance programs are less important in size – 0.7% of expenditures in fiscal 2009 – and more difficult to analyze, as they vary considerably from one state to the other. Moreover, California alone accounted for nearly half of the total spending on these programs.

ELEMENTARY AND SECONDARY EDUCATION

A quick review of the numbers available for states expenditures on elementary and secondary education display a relatively rosy picture. They increased by 3.2% over fiscal 2009, a faster pace than the enrollment growth. Much to the like of Medicaid and welfare programs however, the increase is due to a surge in federal funds (+20.8%). Expenditures coming from the general fund actually declined by 0.5% in FY 2009. The trend accelerated in fiscal 2010, where federal funds increased by a record 35.2%, while states contracted their expenditures by 5.4%. In proportion, the change is impressive: as a proportion of total expenditures, the general fund collapsed from 70.1% to 65.4% in a single fiscal year, a significant transfer of fiscal responsibilities to Washington⁴⁷.

⁴⁷ Moreover, federal funds were traditionally channeled to poor districts and toward children with special needs while they became less targeted with ARRA.

On a spatial dimension, cuts in elementary and secondary education spending have spread relatively quickly. Only 3 regions (New England, Southeast and Far West) witnessed a decrease in state funds in FY 2009, while only a single region had higher expenditure levels in FY 2010 (Great Lakes). The contraction was particularly brutal in certain regions: state funds collapsed by 12% in the Far West in FY 2009, and by nearly 16% in the Southwest the following fiscal year. On the other hand, federal support skyrocketed by 60.2% in the Far West in fiscal 2009, and by 84.1% in the plains in FY 2010.

HIGHER EDUCATION

Higher education spending, which supports public university systems, community colleges and vocational education institutions is far more reliant on state funds than any other expenditure category. In fiscal 2009, general funds and other state funds contribute to finance 85.6% of expenditures, against 10% from the federal government. This contributes to explain the high sensitivity of higher education to economic downturns.

Contrarily to primary and secondary education however, the state budgets for higher education have been spared in this recession. State funds increased by 1.4% in fiscal 2009 and by 0.8% in fiscal 2010, and federal funds increased rapidly (+11.4% and +16.3%) through the ARRA. Cuts were realized in capital projects, which decreased by 2.5% in FY 2009 and by 11% in FY 2010. States also adopted a clear strategy of shifting an increasing share of the financing burden to the students attending their

higher education institutions. For instance, tuition and fees in four-year public colleges grew by 7.9% in 2010.

Geographically speaking, state higher education expenditures stood relatively well in both fiscal 2009 and 2010. Only 5 regions (New England, the Great Lakes, the Southeast, the Rocky Mountain and the Far West) scaled back their spending in 2009 and 2010.

CORRECTIONS

Corrections is another program in which funds from state government are predominant, with 90.2% of all expenditures financed by the general fund in fiscal 2009. Spending has been characterized by an important degree of volatility irrelevant to the variations in the population of inmates. They expanded by 6.2% in fiscal 2008 before stabilizing in fiscal 2009 and contracting by 2.8% in FY 2010, reflecting revenue shortfalls. Although the share of the federal government in state correction spending is low (2.6% in fiscal 2009) it has been growing vigorously in fiscal 2009 and 2010, recording growth rates of 64% and 44.9% respectively. This implies that state funds actually declined over these two years.

TRANSPORTATION

The state transportation programs are characterized by their source of financing, which mixes support from the federal government (30.6% of total expenditures) and earmarked revenues (56.8%). The largest of this revenue is the gasoline excise tax.

Once again, expenditures for transportation have followed during this recession a pattern that has become familiar to us. While federal funding skyrocketed through the ARRA (+34.4% and +22.4% in fiscal 2009 and 2010 respectively), state spending from the general and other funds actually declined 2.4%.

SUMMARY

Spending policies adopted by states during the fiscal crisis have displayed the following pattern:

- Spending increases in fiscal 2009 and 2010 was essentially due to a voluntary policy of the federal government through the American Recovery and Reinvestment Act of 2009;
- States faced significant fiscal pressure over the period, a pressure to which they responded by scaling back every single one of their programs;
- Medicaid remains the most difficult element to control for states and clearly constitute a major budgetary issue in an era of fiscal restraint;
- Large cuts in state and local government payrolls illustrate the tremendous shock on public finances caused by the subprime crisis and the subsequent recession.

An area we have overlooked in this paragraph was the aid state governments provide to cities and other local public authorities. Relationship between state and local governments is as much complex – if not more – than those between Washington and state capitals. While states are often tempted to shift fiscal stress to local governments, in a move referred by experts as “fend-for-yourself federalism”, this can have a boomerang effect. For example, New York State had to seize the finances of one of its counties, Nassau, in January 2011 despite its position as one of the richest county in the nation and its strong tax base. One thing remains certain: states contribute massively to the fiscal health of lower echelons of government. In 2008, 30% of the revenues of local government came from the states.

The incentive for states to transfer part of their budgetary issues to local governments is strong because the latter tend to perform better from a revenue perspective than the former during recessions. Local governments are indeed essentially funded by property tax collections which are far more stable than revenues from income or sales taxes. On the other hand, the situation appeared to have shifted in the third quarter of 2010. Up until then, local governments revenues remained strong, but the lagged impact of falling housing prices is now hitting them hard (Luts, 2008)⁴⁸.

Data on changes in local aid during this recession are not yet available, but the example of the 2001 recession can offer a perspective. Total transfers from states to

⁴⁸ The Case-Shiller Home Price Indices reported that house prices fell by 27% nationally from the year ending in June 2006 to the year ending in June 2010.

cities declined by 9% between 2002 and 2004, depriving them of resources at the time they are most needed. NASBO (2010) suggested that 22 states would reduce their aid to local governments in FY 2010. 20 proposed to do so in FY 2011.

An example of tensed fiscal relations between state and local governments can be found in New York, when New York City mayor Michael Bloomberg dismissed the state budget for fiscal 2012 as an “outrage”. The state of New York indeed scaled back its aid to the City by more than \$400 million, forcing it to readjust its budget. The governor’s office justified the transfer by the fact that “the city revenue position has improved so they have much less pressure on their overall budget”, while a spokesman for the mayor considered that “Albany wants to have it both ways: take credit for a budget with real cuts and take no responsibility for the consequences of those cuts” (Hernandez, 2011).

2.3.5 Taxes, fees and state revenue policies

The economic downswing had a strong recessionary effect on the main components of fiscal revenues for states: sales, personal income and corporate income taxes. In fiscal 2010, collections from these sources amounted to \$592 billion, an 11.7% drop compared with the \$670.5 billion collected in fiscal 2008. The decline in state revenues have been stronger than during previous recessions, as all the sources of revenues declined in 2008-10. The largest drop was experienced by corporate income taxes, which collapsed by 24.8% between 2008 and 2010. Personal income tax

collections fell by 14.9% over the same period, while sales tax declined by 6.5%. The situation improved in FY 2011, with corporate income tax (+12.8%) spearheading a 6.4% increase in collection. Personal income tax revenues continued to lag behind (+4.9%). This is problematic as personal income tax constitutes the largest source of tax revenues in most states. The trend is unlikely to improve given the recent poor performance of the job market and the weakness of the recovery.

In fiscal 2009, personal income taxes accounted for 40.3% of the total collection for the general fund, followed by sales and compensating use taxes (32.4%), other taxes and fees⁴⁹ (19.7%) and corporate income taxes (6.8%). The general fund, as we have seen earlier, does not represent the entire source of revenues for the states. Some programs are indeed funded by particular taxes and fees which are earmarked for specific purposes, such as gasoline taxes, gaming taxes, lottery proceeds and motor vehicle fees

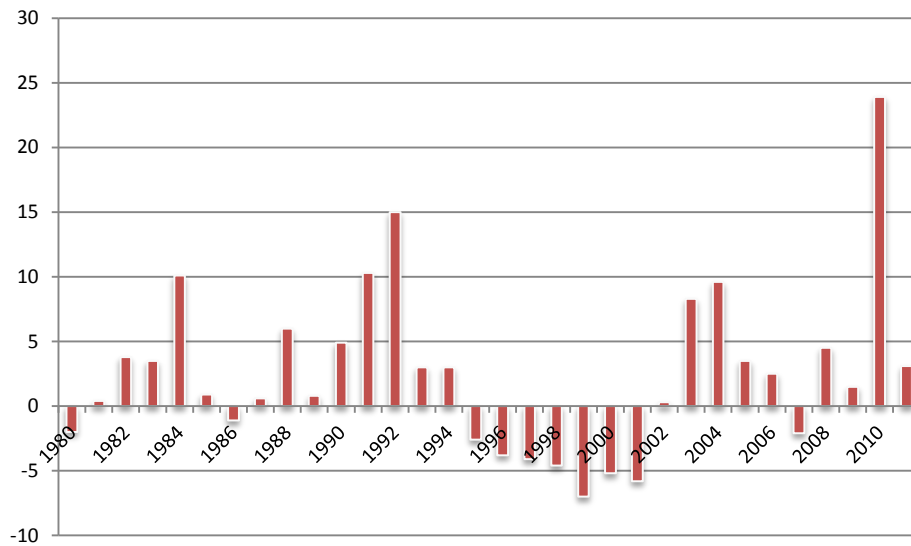
Significant variations in the amount of tax collected brought pressure on states' forecasts, with 46 states overestimating their revenues in fiscal 2010, even more than the 41 states concerned in FY 2009. Only two states were on target (one in 2009) and two exceeded their estimations (four in 2009).

States addressed the issue by enacting \$23.9 billion of tax and fee changes in fiscal 2010. The effort was not renewed in fiscal 2011, with only \$3.1 billion in net tax and

⁴⁹ Most commonly: taxes on tobacco and alcohol, insurance premiums, severance taxes, licenses and fees for permits, inheritance taxes and charges for state-provided services.

fee increase recommended by governors. 18 states proposed net increases, and half of that number net decreases.

Figure 2.26. Enacted State Revenue Changes (\$ in billions)



* Proposed state revenue actions for FY 2011

Source: Advisory Commission on Intergovernmental Relations and NASBO

2.3.6 Mid-Year Budget Cuts

For legislative and political reasons, budget cuts tend to be the favored strategy to generate short-term savings and maintain the budget in balance. In times of revenue volatility, states usually find it necessary to amend their enacted budget to address circumstances that were unforeseen. Because legislating revenue increases is very difficult during the fiscal year, governors and legislatures are biased toward expenditure-related measures in their quest for balancing the budget. In 2002, thirty-seven states cut approximately \$12.6 billion from their enacted FY 2002 budget to answer the economic downturn caused by the dot-com burst. And the budget shortfalls

during this previous recession were somewhat moderate when compared to those following the recession of 2007.

As such, the most indicative element of fiscal stress at the state level following the recession has been the widespread implementation of mid-year budget cuts in both FY 2009 and FY 2010, concerning more than 40 states. 23 states continued to implement the strategy in FY 2011, cutting approximately \$7.8 billion. During the whole crisis, the program areas most likely to be affected by mid-year retrenchments were K-12 and higher education, with Medicaid and corrections following. Between fiscal 2009 and 2011, states have already filled more than \$230 billion in budget gaps. 12 states expected to face \$12.1 billion in budget gaps before closing fiscal 2011, and the prospects for FY 2012 (33 states, \$75.1 billion) and 2013 (21 states, \$61.8 billion) remain depressed.

Regression analysis proposed by Inman (2010) identifies the unemployment rate as the most important correlate to mid-year budget cuts. This confirms our intuition that state employee layoffs, along with mid-year budget cuts, are particularly good indicators of the degree of fiscal stress experienced by states. Another finding is that states with larger populations, such as New York, tend also to have larger per capita deficit gap. Finally, and interestingly enough in the case of New York State where manufacturing has been in constant decline, the importance of the manufacturing sector in a regional economy seems to dampen the size of anticipated deficits. This analysis thus offers a

strong critic of the structural deficit argument, attributing most of the downswing in general revenues to the surrounding economic conditions⁵⁰.

Table 2.6. Ten largest budget cuts after the enactment of FY 2009 and FY 2010 Budgets

FY 2009		FY 2010	
State	Size of cuts (\$ in millions)	State	Size of cuts (\$ in millions)
1. California	10,399.2	1. Florida	3,000
2. Georgia	2,262.2	2. Massachusetts	2,394
3. New Jersey	1,760	3. New Jersey	2,028
4. New York	1,700	4. Georgia	1,253.4
5. North Carolina	1,211	5. Kentucky	1,110.5
6. Ohio	1,165.8	6. New York	1,083
7. South Carolina	1,106.5	7. Virginia	1,044
8. Massachusetts	946	8. California	1,000
9. Florida	887.4	9. Indiana	726.5
10. Indiana	767.4	10. Oklahoma	709.1

Source: NASBO

Despite the complex nature of raising revenues during the fiscal year, 7 states managed to do so in FY 2011, for a total of \$3.6 billion. Modifications in personal income taxes accounted for nearly every dollar of additional revenue. But the preferred method for eliminating the gaps remained targeted cuts (34 states), across-the-board cuts (20 states), layoffs (20 states) and furlough programs (19 states). In rare occasions (9 states) rainy-day funds were used to cushion the shock.

⁵⁰ Note that this does not necessarily apply to individual states. The example of California is here telling.

CONCLUSION

Despite the magnitude of the fiscal crisis of 2008-10, state budgets have remained on average remarkably stable in their structure. This stability is clearly the by-product of an extensive support from the federal government through the American Recovery and Reinvestment Act of 2009. The vast majority of policy implemented during the recession and its aftermath can be considered textbook cases when analyzed in the view of past experiences. Much like in the early 1990s, states have been eager to finance their higher education system by raising tuition, including rates for in-state students⁵¹, transferring Medicaid costs to the federal government, cutting down on welfare spending and aid to local governments. This however did not alter the great transformation that state finances have underwent since 1970, that is the increasing share occupied by health expenditures in their overall budget. On the revenue side, tax systems were not significantly reformed following the recession. As in the early 2000s, governors and state legislatures have proven particularly reluctant to raise taxes to fund their booming deficits, leaving expenditures burden most of the fiscal stress.

This does not imply however that state policies have remained static and that a new era of fundamental transformation in state public finances is not at hand. Despite the end of the revenue crisis in 2010, the fiscal crisis continues, fuelled by a slow economic recovery and the associated modest revenue growth. The end of massive federal aid programs and lagged tensions caused by Medicaid expenditures, unfunded

⁵¹ For instance, undergraduate tuition is expected to rise at an annual rate of 5% over the next five years for in-state students attending the State University of New York (Kaplan, 2011). Tuition at the University of California is planned to rise up to 16% annually over four years.

pensions and the overuse of fiscal gimmicks to balance the budget will likely usher reform in the expenditure and revenue system. Even though there exists a strong opposition to tax increases in the United States, tax reform is perceived as a valid alternative.

The “reformist” perspective has been criticized by a certain number of practitioners, including the former New York State budget director Dall Forsythe who strongly believed that budget scarcity actually caused state and local governments to deviate from seeking efficiency when redeploying and re-imagining services (Forsythe, 1993).

Beyond the question of efficiency and public management lies also the question of equity. As we repeated numerous times in this chapter, state expenditures in all areas – once corrected for federal funds – have declined since the start of the recession. This raises equity issues in that certain populations may be more affected by cutback management than others. Students attending higher education institutions may have to pay higher tuition fees, low-income household may face a decrease in their benefits and state employees can lose their jobs or see their pensions reduced. The interest of using a model such as the social accounting matrix, as we will propose in chapter IV, becomes clearer in this perspective as it is able to address both the equity and efficiency of fiscal policies in the same framework.

One thing has been established in this chapter. During recessions, state legislators and governors operate in a highly unstable fiscal environment, where revenues – from

taxes and the federal government – and expenditures can vary abruptly and are complex to forecast and to organize efficiently (Ward, 2011). Given that most states are constitutionally obligated to balance their budgets, this implies that legislatures must take drastic actions to insure that revenues and expenditures remain in line for the current fiscal year and for upcoming ones. In the short term, it means that states can cut services and increase revenues only to realize a few months later that their deficit is still expanding. Managing these mid-year budget cuts prove tricky, especially when the deficit resulting from the business cycle is piled on a pre-existing structural deficit.

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Chapter III

OVERVIEW OF NEW YORK STATE'S PUBLIC FINANCES AND ECONOMY

The economic downturn and the impact of the Lehman shock on the financial sector have crippled the short-term budget situation and the long-term economic prospects of New York State, a situation that aggravated the structural imbalances the state has faced for decades. Intense fiscal stress was quickly reflected by the appearance of mid-year budget gaps which peaked in fiscal 2009, topping \$3 billion. The analysis presented in this chapter points out to the role of the dependence of Albany's revenues on personal income taxes in the emergence of budget shortfalls, and to the increasing cyclicity of the state's resources (section 3.2). It further elaborates on the budget process and the actors that animate it (section 3.3) before offering a brief overview of how the state government decided to respond to increased fiscal stress and attempted to close burgeoning gaps (section 3.4). Finally, the structure of New York State's economy and its characteristics are described (section 3.5).

3.1 Some Definitions

Before introducing this chapter with an overview of New York State's fiscal environment, we would like to provide the reader with a number of definitions provided by the National Association of State Budget Officers (NASBO) that will help with the material developed in the following pages.

Definition 3.1. *General Fund:* The predominant fund for financing a state's operations. Revenues are received from broad-based state taxes. There are differences in how specific functions are financed from state to state, however.

Definition 3.2. *Federal Funds:* Funds received directly from the federal government.

Definition 3.3. *Other State Funds:* Expenditures from revenue sources that are restricted by law for particular governmental functions or activities. For example, a gasoline tax dedicated to a highway trust fund would appear in the "Other State Funds" column. For Medicaid, other state funds include provider taxes, fees, donations, assessments, and local funds.

Definition 3.4. *Bonds:* Expenditures from the sale of bonds, generally for capital projects.

Definition 3.5. *State Funds:* General funds plus other state fund spending, excluding state spending from bonds.

Definition 3.6. *Revenues:* Revenues comprise all money received by a government from external sources (that is, originating from "outside the government"). Statistics on state government finance include measurement of revenues by type (e.g., sales taxes, income taxes, intergovernmental revenues). For states that operate video lottery terminals, total income includes net revenue from the video lottery. Revenue does not include money a government has borrowed, although profits from the sale of cash and securities as well as proceeds from the sale of fixed assets are classified as revenues.

Definition 3.7. *Expenditures:* Expenditures comprise all amounts of money paid out by a government during its fiscal year, with some exceptions. Statistics on state government finance include measurement of expenditures by character (e.g., current operations, capital outlay, intergovernmental expenditures, and so on) and function (e.g., education, health, public welfare, natural resources, and so on). Expenditure does not include a government's payment of its debt, or purchases of investment securities, loans it has granted, agency or private trust transactions, nor correcting transactions.

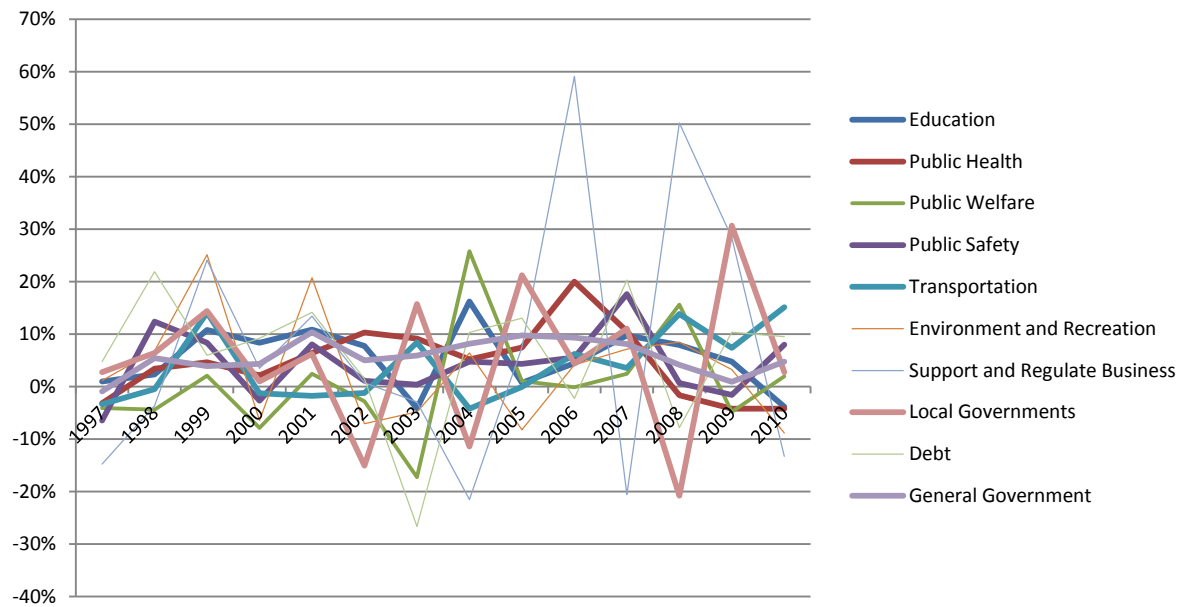
3.2 Fiscal Environment and Budgetary Issues in New York State

3.2.1. General Performance

New York State offers a number of particularities that distinguishes it from other states, in particular what has been repeatedly characterized as a low level of transparency in budget decision-making (Bifulco and Duncombe, 2010), lax budget balance requirements and a relatively centralized budgeting power with the executive branch at its center. This centralization of the budget process is however counter-balanced by the disproportionate size that New-York City occupies in the regional economic landscape. New York State, as such, represented only 36% of all local government expenditures in fiscal 2006, and only 46% of taxes. This is significantly inferior to the national averages, at 43% and 59% respectively.

New York's reputation of a liberal state with a large and expansive government is therefore not as deserved as aggregated data might suggest: in 2006, state and local government expenditures per dollar of income were 12% higher than the national average, while taxes collected per dollar of income were 23% higher. When standing alone, New York State expenditures and taxes relative to income were 8% and 2% below the country as a whole respectively.

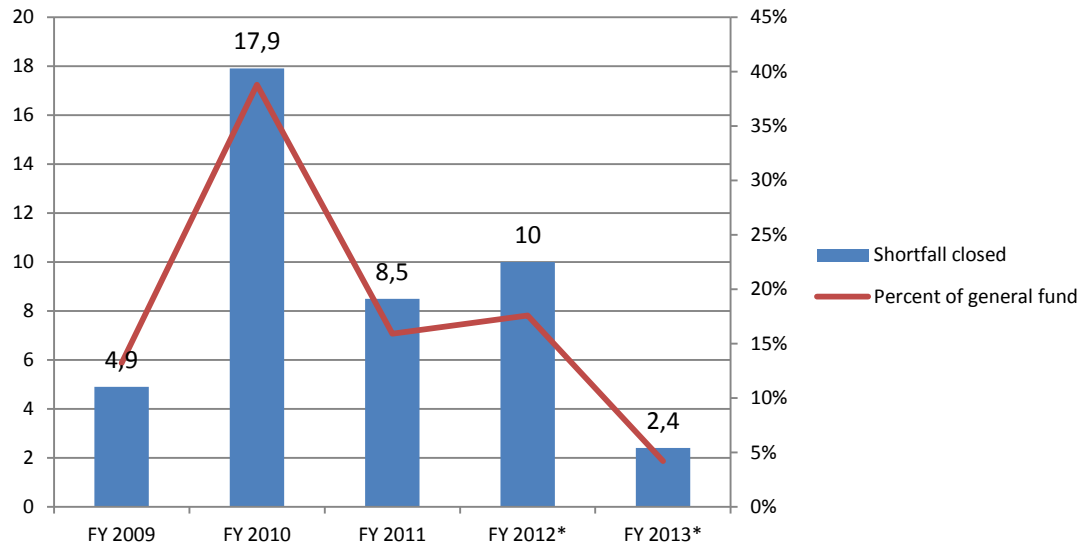
Figure 3.1. Annual growth rate of money spent by major service function



Source: Office of the State Comptroller

It is however true that the state's spending have increased rapidly over the 2000s, throwing the public finances over the edge. The state repeatedly faced important budget gaps during the Great Recession, and gaps larger than the billion dollars are expected up until fiscal 2013 (Division of Budget, 2011).

Figure 3.2. Shortfall closed after adoption of the budget (\$ in billions)



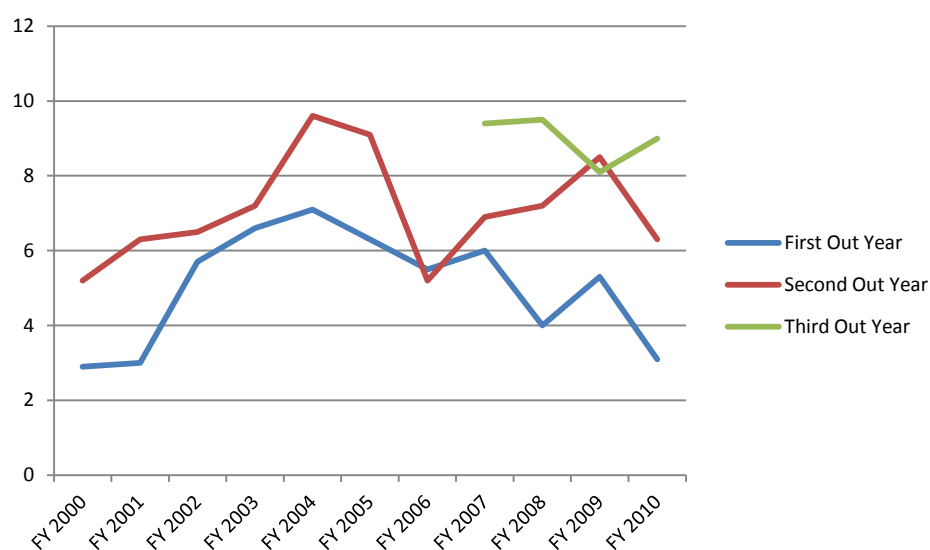
* Estimates

Source: Division of Budget

It is difficult to judge the degree of fiscal stress from the simple magnitude of the budget shortfalls because of the widely different size of the states' general fund. Shortfalls measured as a percentage of the general fund budget is thus a better indicator of the deterioration of public finances. At the onset of the fiscal crisis, in FY 2009, New York State actually performed better than the national average, with a budget shortfall representing 13.2% of its general fund, against 15.2% for the whole country. But its situation considerably deteriorated in fiscal 2010, where its shortfall boomed to 38.8% of general funds, against a national average of 29%. In fiscal 2011, New York again fared better than the national average, its abysmal \$17.9 billion gap reduced to an \$8.5 billion shortfall, representing 15.9% of the state's general fund, lower than the national average of 19.9%. In fiscal 2012, New York is expected to face a budget shortfall in line with the whole country: 17.9% against 15.9%. In terms of ranking, New York State only made the top ten of largest budget shortfall as a

proportion of the general fund in 2010 (#6), and barely in 2012 (#9). Focusing on the period 2009-11 only, it outperformed New-Jersey, California, Arizona, Illinois and Nevada in every year.

Figure 3.3. General fund out year deficits in proposed executive budget (% of expenditures)



Source: Bifulco and Duncombe, 2010

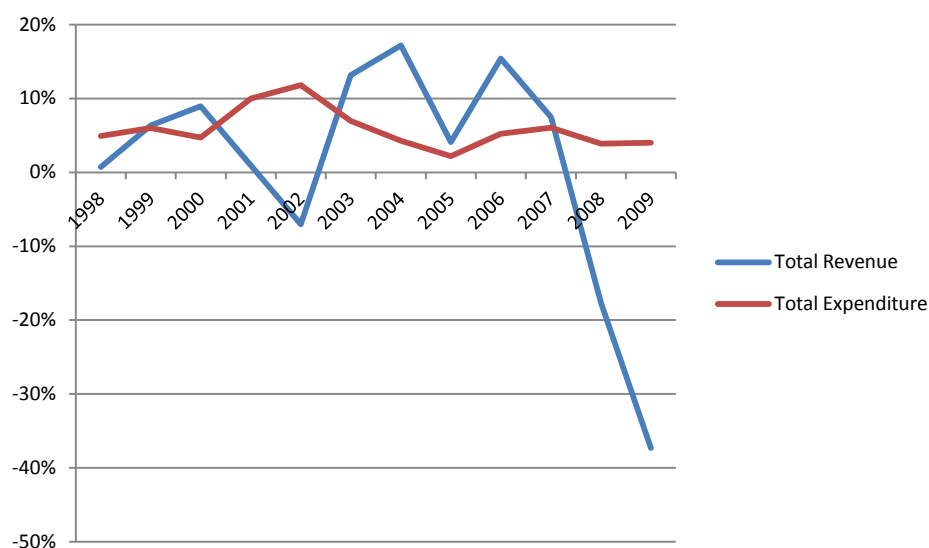
3.2.2 Sources of the Budget Deficits

AN OVERVIEW OF THE CYCLICAL AND STRUCTURAL FACTORS

The growth of New York State spending has been driven by the new commitments taken by Albany without enacting corresponding revenue measures. For instance, the state took over counties' part of Medicaid costs and all their shares in Family Health Plus, expanded the STAR program and carried on significant investment campaigns for transportation infrastructure and higher education. On the

other hand and starting in the mid 1990s, the legislature enacted several rounds of multi-year back-loaded tax cuts which depressed annual revenues by an estimated \$20 billion (Fiscal Policy Institute, 2009).

Figure 3.4. New York State Total Revenue and Total Expenditure Growth (in percent)



Source: U.S. Census Bureau

The level of public spending in New York State can nevertheless not be only attributed to cyclical factors. Demographically, the state is characterized by a high degree of urbanization, large immigrant communities and strong pockets of poverty. Empirical studies realized by Ladd and Yinger (1991) and Duncombe and Yinger (2008) suggest that ageing infrastructure, population and higher than average poverty rates translate into fiscal stress for local and state governments and higher costs of provision of public services, including education, housing and welfare. On the political side, Forsythe and Boyd (2006) remarked that neither the Democrats nor the

Republicans have articulated their fiscal rhetoric around budget conservatism, limiting the opposition to increased spending and borrowing. The size of the public sector has also made public unions particularly powerful, limiting the likelihood of significant spending reduction programs.

Structural factors bequeathed a large long-term outstanding debt – the ninth largest among states – and rising costs to service it. In fiscal 2009, the state spent 6.4% of its general fund on debt service, or \$5.2 billion. The debt burden is even heavier for local governments, making the policy of shifting costs to them more complex. Consequently, New York State has been plagued by recurring budget gaps for most of the past thirty years. The last ten executive budgets all forecasted that expenditures growth would outpace revenue increases, creating budget shortfalls ranging between 5% and 9% of disbursements even when the economy was booming⁵².

Perhaps the most striking explanation of the demise of New York State's public finances is the apparent contradiction that has been structuring its economy for most of the past two decades. Despite a highly-educated population, the presence of New York City and the state's leading position in many dynamic tertiary sectors – in particular finance, real estate and business services in general – New York has been trailing the nation in terms employment growth, which averaged a whopping yearly 0.2% or 40% of the national average. Even during the Clinton years, which saw dramatic economic and workforce expansion, New York underperformed the rest of the country in terms

⁵² See the governor proposed budget for fiscal 2006.

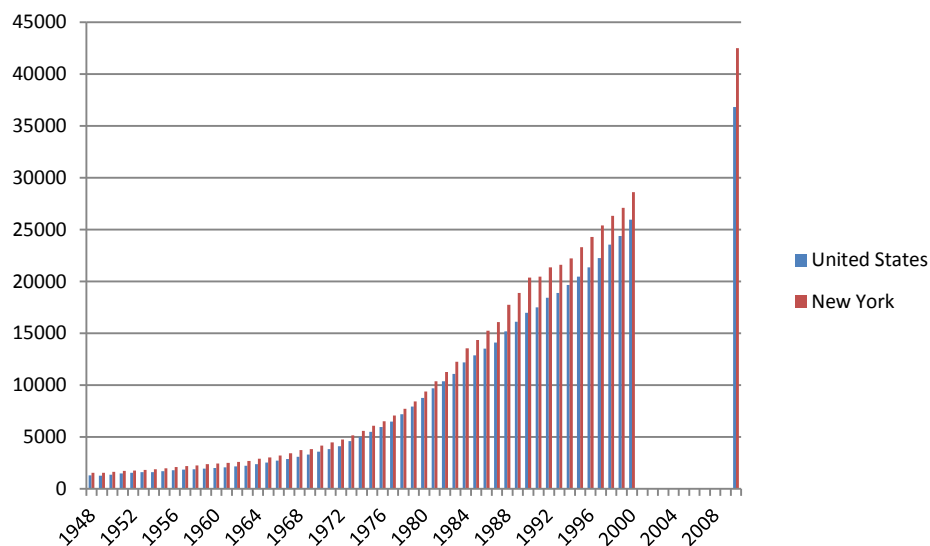
of employment growth (0.5% against 1.9% nationally). This may be partly explained by the tremendous transformation its economy underwent since the post-war years (vom Hofe, 2002). The manufacturing-oriented industrial base located in upstate New York – along the Erie Canal – has declined in favor of New York City, and manufacturing pursued its decay well into the 1990s and 2000s. The New York State Department of Labor estimates that manufacturing employment in the state eroded by nearly 50%, twice the national level. The emergence of the so-called “new economy” has been a headache for policy makers in Albany and local governments, in particular when it comes to promoting the economic development of upstate New York and the vacuum left by the extinction of its manufacturing industries.

THE REVENUE SIDE: INCOME AND TAX VOLATILITY

To compensate for the loss of employment in manufacturing and associated labor income, New York State and New York City have been piggybacking on the region’s top income earners and a relatively strong income growth (Bahl and Duncombe, 1991). Between 1948 and 2008, the per capita disposable personal income⁵³ as well as total average compensation per job in New York State has constantly been higher than the corresponding figures for the entire country. In 2010, the last year for which data were available, per capita disposable income was 15.4% higher in New York State than it was in the United States as a whole. Income appears however counterbalanced by a higher volatility in New York State.

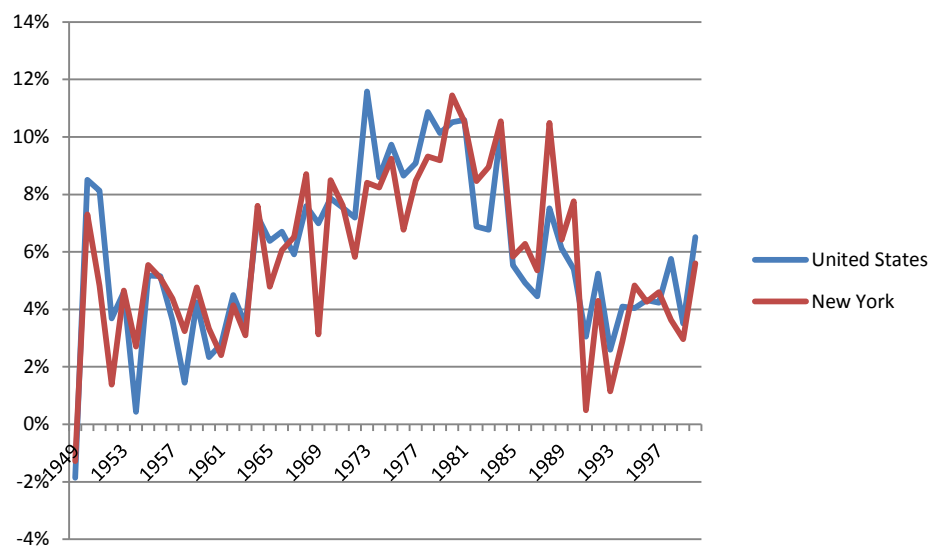
⁵³ Total disposable personal income divided by total midyear population.

Figure 3.5. Disposable personal income in New York State and the U.S. (in current dollars)



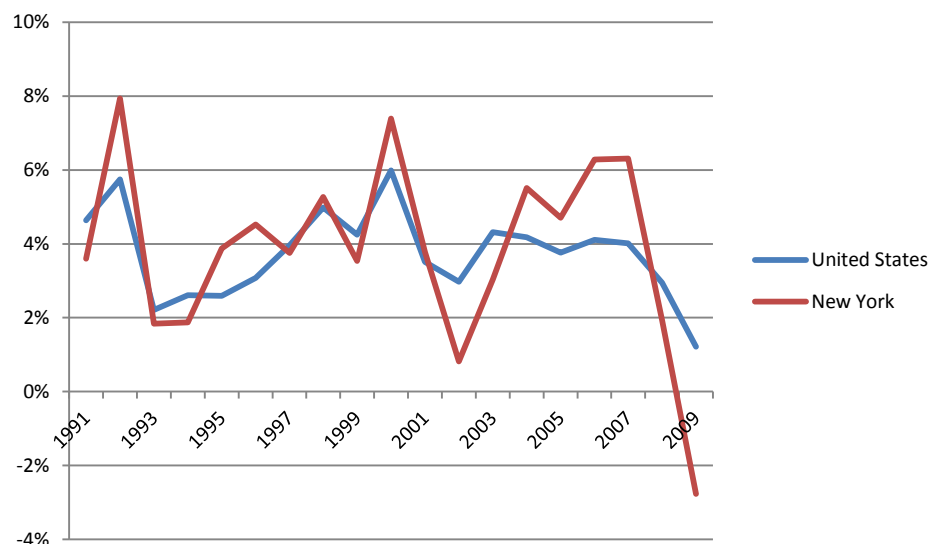
Source: Bureau of Economic Analysis

Figure 3.6. Annual growth rate of disposable personal income in New York State and the U.S.



Source: Author's calculations, from BEA

Figure 3.7. Annual growth rate of total average compensation per job



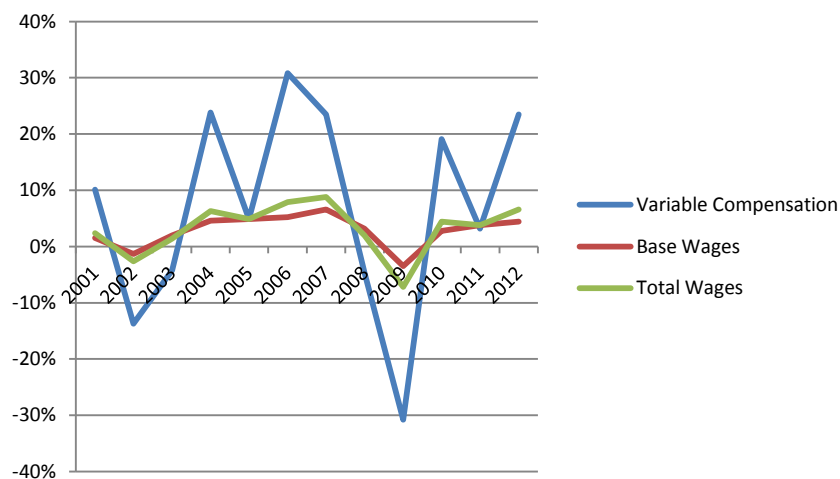
Source: Author's calculations, from BEA

This volatility of income stems directly from the state's over-reliance on the variable wages of the financial sector. The catastrophic effect this may have on public finances is clearly illustrated by the following statistics: total wages dropped by 7.2% in 2009, which, although the largest yearly contraction on record, pales in front of the collapse of variable wages. The latter decreased by almost 31%, or \$21.6 billion, to \$48.5 billion⁵⁴. With the economic ground gaining momentum in early 2010 and inflationary pressures kept at bay, the outlook for wages looked promising. However, much of the improvement can be attributed to variable compensation, while base wages struggle to reach their pre-recession growth pace. This is somewhat worrisome, as a one percent decline in personal income can cause a drop in income and sales tax revenues superior to one percent for the fiscal year (Bruce et al., 2006). The fall of revenues from the income tax, at 2.7%, explains most of the drop.

⁵⁴ In 2007, variable compensation amounted to \$73.4 billion.

Although the share of variables compensation in total wages is still low – approximately 12% from 2004 to 2008 – it has progressed significantly since the start of the deregulation of the financial industry in the 1970s (5%). Consequently, the volatility of variable compensation is an increasing determinant of the evolution of wages in the state of New York. In 2010, the New York State Assembly Ways and Means Committee staff estimated that finance and industry alone accounted for more than half of variable wages, with bonus pools from the securities industry at the vanguard. This characteristic of the state economy is troubling, particularly given the new set of rules established by the Dodd-Frank bill and Basel III. As employment growth, profitability and variable compensation lose steam in the securities industries, wages progression in New York State is likely to slow down even further, compromising the revenues that Albany derives from its income tax.

Figure 3.8. Wage growth in New York State by components

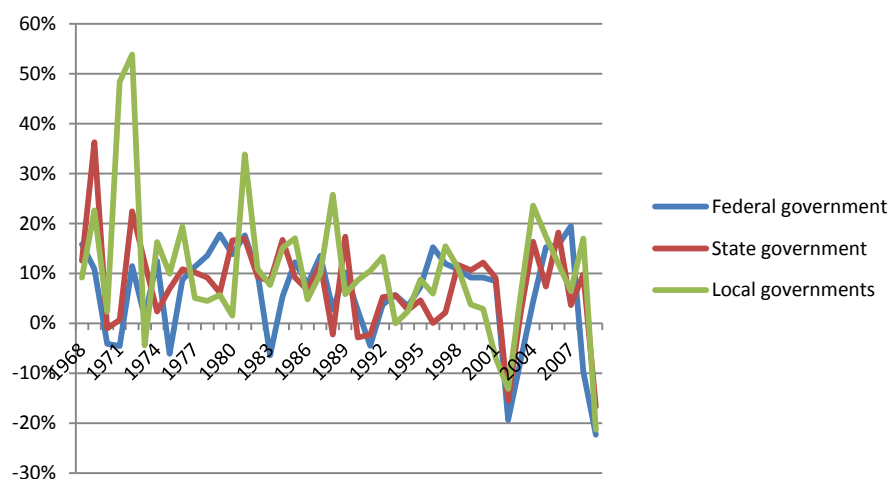


Note: Data for 2010 are estimated. 2011 and 2012 are forecasts

Source: NYS Department of Labor, NYS Assembly Ways and Means Committee staff for estimates

This volatility and the transformation of New York State's economy had a nefarious effect on the stability of the revenues that Albany draws from its tax base. It is very clear that the growth in tax receipt has become more sensitive to both upswings and downswings during the 2000s. During the “go-go” years of 2004-2008, tax revenues increased by a yearly average of 11% before contracting violently by 16.7% in FY 2009. State revenues from taxes rely on a mix of four different instruments: individual income tax, corporate income tax, sales tax and a combination of other minor taxes. The economic crisis caused all these sources to dry up simultaneously, a phenomenon that had not occurred since the 1980s recession (Deitz et al., 2010).

Figure 3.9. Growth rate of personal current taxes in New York State by level of government



Federal government: Income taxes net of refunds, including the federal fiduciary income tax

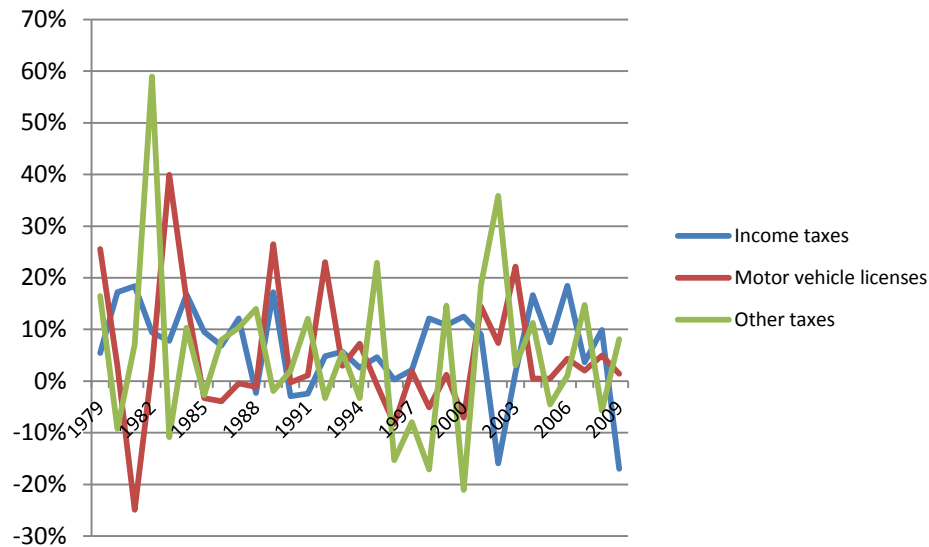
State government: Income taxes, motor vehicle licenses and other taxes (consisting largely of hunting and fishing taxes and other license taxes)

Local governments: Income taxes, motor vehicle licenses and other taxes; tax receipts growth for FY 1959 (+106.9%), FY 1965 (+587%) and FY 1967 (+1777%) have been eliminated for readability

State and local personal property taxes are excluded

Source: Author's calculations, from BEA

Figure 3.10. Growth rate of state tax revenues in New York State by sources

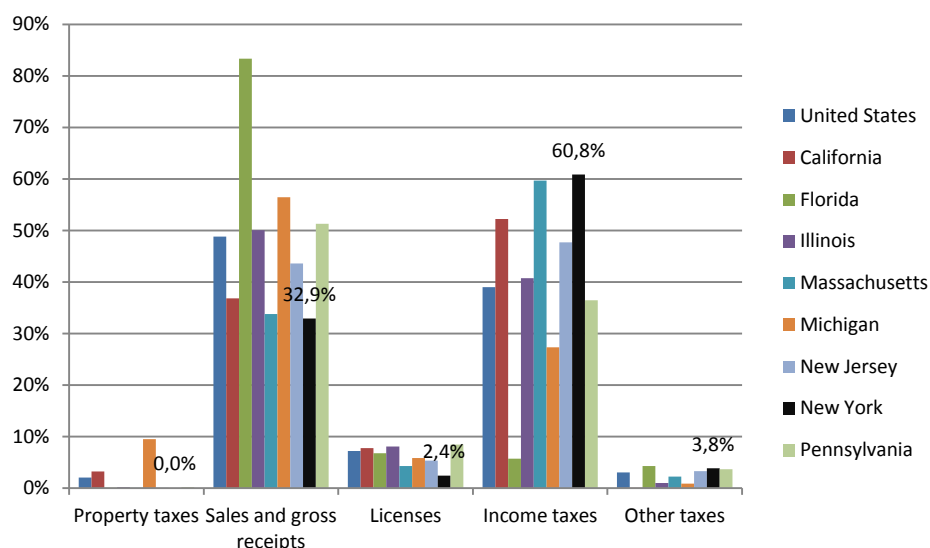


Source: Author's calculations, from BEA

Tax receipts volatility is a direct consequence of the tax structure adopted by New York State, which – very similarly to what happened in neighboring New Jersey – relies more on personal and corporate income than other states. As illustrated in figure 3.12, New York State drew approximately 61% of its tax receipts from personal and corporate income, significantly higher than the national average. Increased dependence on these taxes has made New York revenues more sensitive to the business cycles. High volatility is also due to the central place taken by the financial and real estate industries in tax revenues. According to the fiscal 2009 *Executive Budget Briefing Book* (DoB, 2008), the financial services sector accounted for approximately 20% of state tax revenues in the 2000s. A significant portion largest economic crises since the Reagan era of deregulation has involved or affected an industry in the financial sector, from real estate to hedge funds and investment banking. This implies that the very structure of the tax base in New York State is ill-

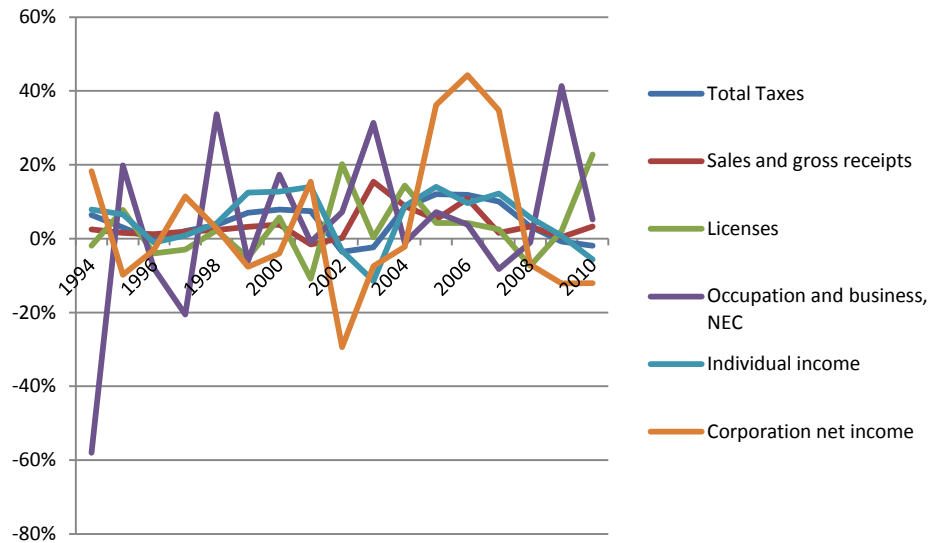
adapted to cushion the shocks that have become the most likeliest to occur, i.e. financial crises. The dependence of New York State tax revenues, tied to the performance of the financial sector, is therefore narrowing geographically to the economic health of New York City. Indeed, if New York City accounted for 43% of total nonfarm employment in the state, it concentrates more than half of the wages paid there. As the financial district shed an increasing number of highly paid and highly qualified jobs, the state finances crumbled. The sensitivity of New York State's revenues to the health of top income earners and to capital gains is illustrated by the fact that according to the Division of the Budget the upper half of the top income earners paid 30% of the state's personal income tax in fiscal 2009. As for capital gains, they accounted for approximately 25% of all income taxes.

Figure 3.11. Structure of state governments tax collections (FY 2010)



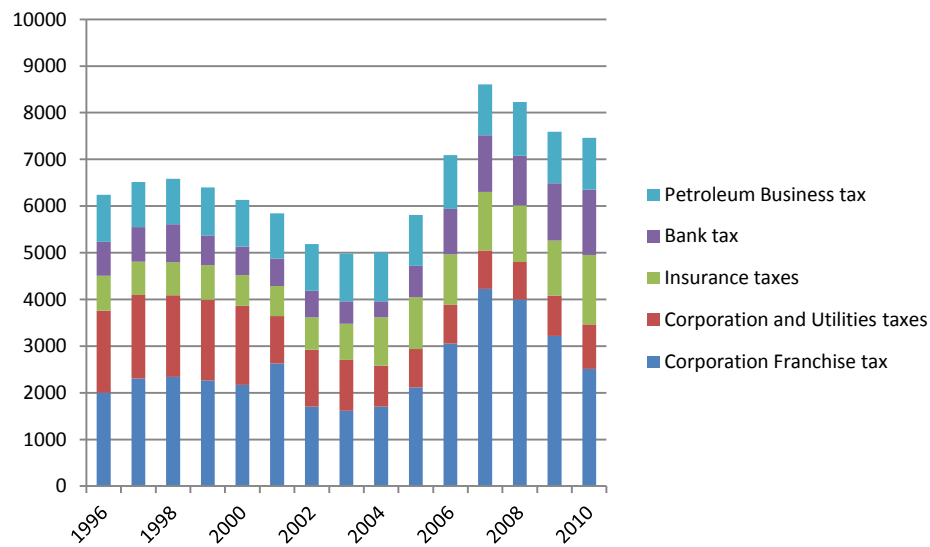
Source: Author's calculations, from U.S. Census Bureau

Figure 3.12. Annual growth rate of tax collections by type



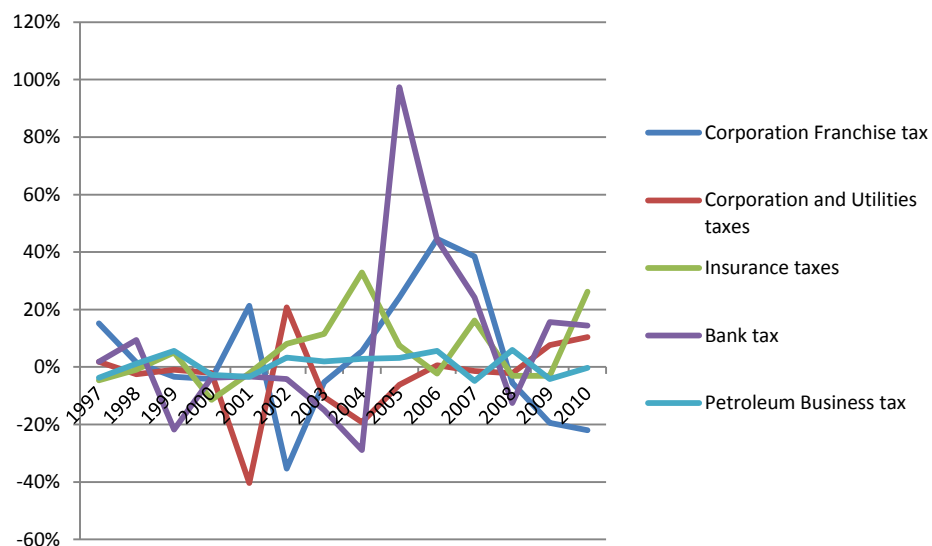
Source: Author's calculations, from U.S. Census Bureau

Figure 3.13. Composition of the Business Tax in New York State



Source: Office of the State Comptroller

Figure 3.14. Annual growth rate of the components of the business tax



Source: Office of the State Comptroller

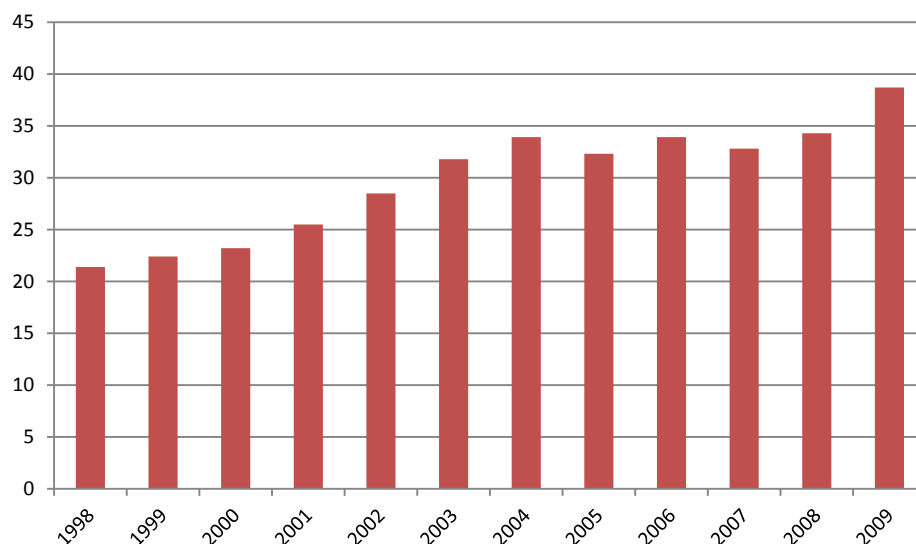
THE EXPENDITURE SIDE: INCREASED SPENDING ON MEDICAID AND EDUCATION

a. Medicaid

Medicaid costs⁵⁵ increased exponentially after the financial crisis, rising by more than \$4 billion (+12.9%, +4.6% in FY 2008) in fiscal 2009 alone.

⁵⁵ Note that New York State asks its counties to make significant contributions to the financing of Medicaid. They cover approximately 16% of the total bill, but since FY 2006 growth of expenditures on the program has been capped to 3%.

Figure 3.15. New York's Medicaid Costs (\$ in billions)

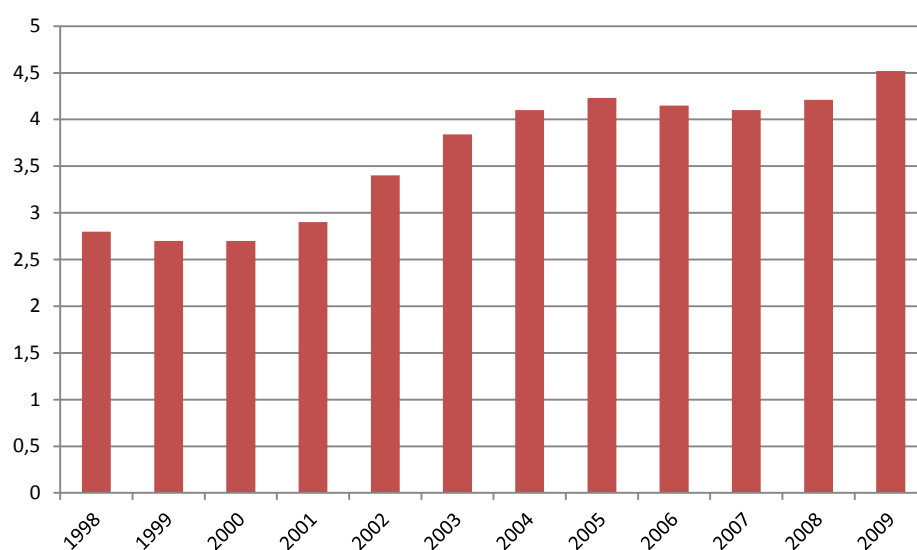


Source: Office of the State Comptroller

In fiscal 2010, Medicaid enrollment rose by 10.1%, more than the national average of 8.1%. The impact of the economic downswing on unemployment led the number of eligible recipients to rise significantly (+7.6%, against +2.5% in FY 2008), explaining part of the additional strain on public health expenditures. The increase in eligible recipients was driven by adults (+4.2%, against +3.2% in FY 2008), but the largest single recipient group remains children (+2.3%), with over 1.7 million enrolled in Medicaid coverage. However large these groups, they represented a third of Medicaid costs, while the elderly, blind and disabled (+1%), making up a quarter of all eligible recipients, accounted for the remaining two-third of costs. Beside the effect of the crisis, the increase in the number of eligible adults can be explained by the change in allowable Medicaid resource levels that made a number of persons switching from the

Family Health Plus⁵⁶ program (-20.2% and -6.6% in FY 2008) to Medicaid. Even as the recovery takes a hold and unemployment shrinks, the implementation of the Affordable Care Act is anticipated to increase the number of people eligible to Medicaid after 2014.

Figure 3.16. Medicaid eligibles in New York State (in millions)



Source: Department of Health, based on each year's current claims

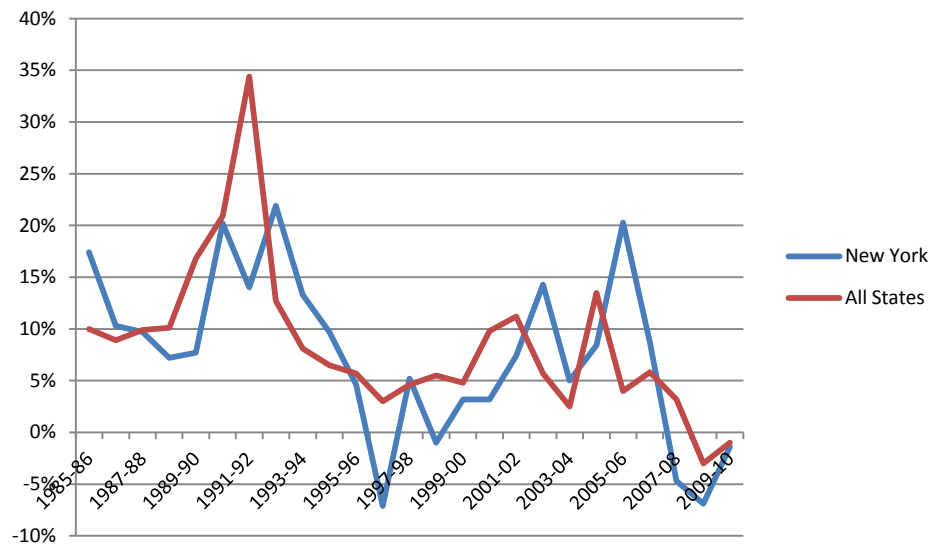
As for spending in public health *per se*, it is relatively difficult to agree on a specific data set. Indeed, figures from all the main sources on New York State public finances, the U.S. Census Bureau, the Bureau of Economic Analysis, the National Association of State Budget Officers, the New York Division of Budget and the Office of the State Comptroller, differ widely. Contrarily to Bifulco and Duncombe (2010), we prefer to use the data published by the Comptroller and NASBO because, as opposed to the

⁵⁶ Initiated in FY 2001, Family Health Plus is a Medicaid expansion program for adults without health insurance but earning income or having resources too high to qualify for Medicaid.

first-quarter and mid-year updates of the Division of Budget, they gather information *a posteriori*, instead of forecasts. One thing remains certain, state Medicaid expenditures are expected to boom over fiscal 2012 (+18.6%) to compensate the sharp decline in federal funding (-13%) due to the termination of the enhanced Medicaid match rate introduced by the Recovery Act⁵⁷.

To react to the additional burden created by the expansion of Medicaid, almost all state governments implemented cost containment measures.

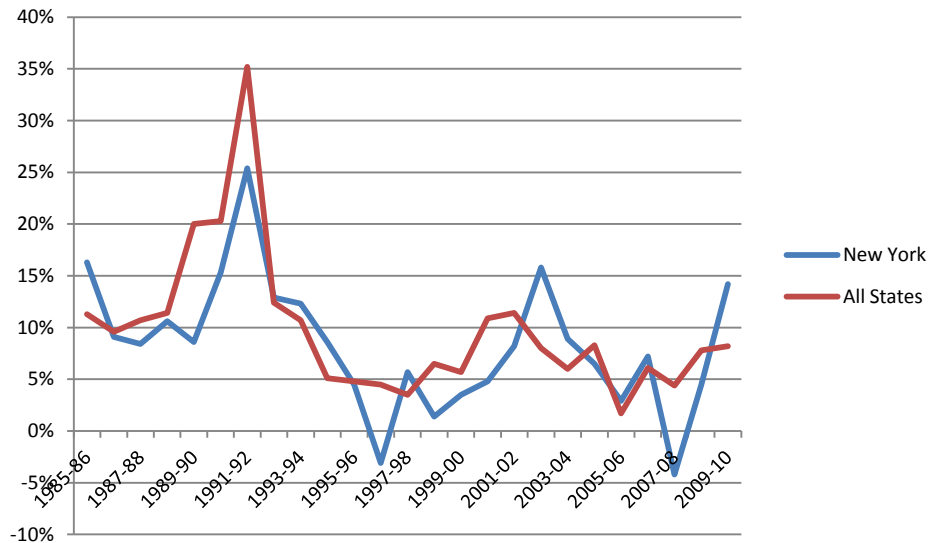
Figure 3.17. Annual percentage change in total state funds Medicaid expenditures



Source: NASBO

⁵⁷ ARRA will end in June 2011.

Figure 3.18. Annual percentage change in total Medicaid expenditures



Source: NASBO

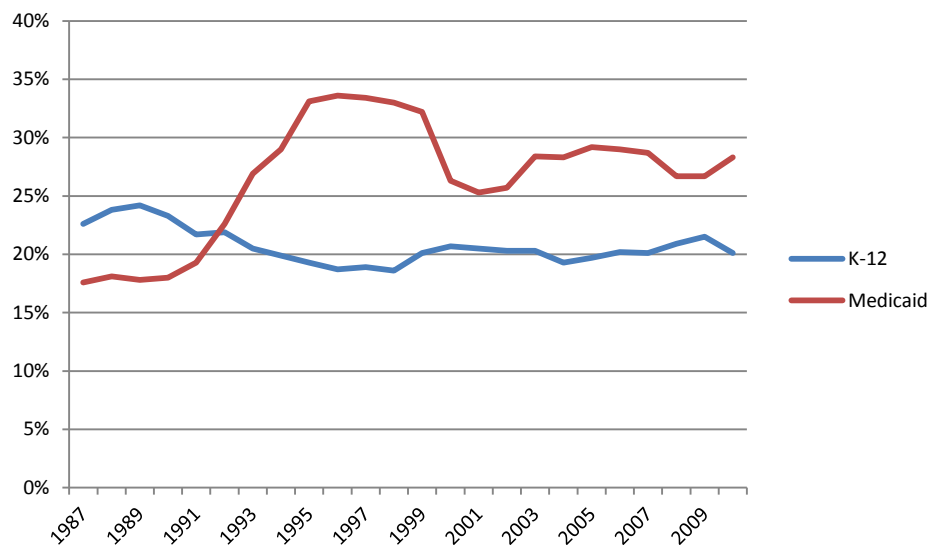
b. Education

Another major area of expenditure for New York State – and states in general – is education, a category that gathers both K-12 and higher education. According to data from NASBO (2010), expenditures of states in elementary and secondary education actually declined in fiscal 2009⁵⁸ (-0.5%), a trend only reversed by the intervention of the federal government through ARRA. This was expected to be all the more true in fiscal 2010, when state funds were estimated to have shrunk by 5.2%, while federal funds jumped by 35.2%. New York State followed a similar path by expanding its expenditure in K-12 education by 8% in fiscal 2008 before reducing it by 2% in fiscal 2009. It however enjoyed important support from the federal government, which expanded its funding by 5.1% and 19.4% in FY 2008 and 2009 respectively.

⁵⁸ The last year for which figures are available.

The largest component of New York State's expenditures on K-12 education is in the form of aid provided to school districts. In fiscal 2006, New York had the second highest education spending per pupil in the U.S. As a percent of total expenditures, spending on K-12 education was 20.9% and 21.5% for fiscal 2009 and 2010 respectively, in line with the U.S. average of 21.7% and 20.8%. The New York State Commission on Property Tax Relief (2008) explained the expensiveness of the state's elementary and secondary education system by teacher salaries, which are 17% higher than the national average and growing benefits. However, the main probable cause is the burden imposed by the School Tax Relief (STAR) program. Started in the early 1990s, STAR is indeed entirely financed by states and amounted to \$4.4 billion in fiscal 2008.

Figure 3.19. K-12 and Medicaid expenditures as a percent of total state expenditures



Source: NASBO

3.3 The Budget Process in New York State

The rules defining the authority, roles and duties of the different branches of the state government are gathered in Article 7 of the New York State constitution. The State's fiscal year begins on April & ends on March 31, and the entire budget process approximately spans 27 months. The model used in the budget process is executive in nature, as the responsibilities for initiating, preparing and balancing the budget rest with the Governor (Article 7, section 2). In order to do so, the Governor consult agencies of the State government and coordinates their requests. Coordination is realized through the emission of a “call letter”, through which the Budget Director – appointed by the Governor – outlines policy priorities, fiscal constraints and the schedule for the upcoming fiscal year.

Figure 3.20. Budget Process in New York State



Source: NYS Division of the Budget

The process is then handed over to the state's Division of the Budget (DoB), with legislative oversight. In particular, the DoB conducts hearings to assess and discuss the needs of the government's agencies. In parallel, the DoB, along with the two chambers of the state's Parliament and the Office of the Comptroller released their forecasts of revenues and expenditures. The final executive proposed budget is then formulated

Beyond proposing a recommended budget and associated appropriations bills for every fiscal year, the executive can limit the changes that the legislature wishes to bring to the budget through the line item veto. Moreover, the legislature cannot actually raise the level of individual appropriations determined by the governor, meaning that the latter has indeed the power to lay down an upper cap on the budget. The legislative branch can however add new appropriations to the budget (Article 7, section 4), which the governor can in turn veto (Article 4, section 7). To override the veto, the legislature needs at least a two-third vote⁵⁹. The preeminence of the Executive over the budget has been confirmed by the New York State Court of Appeals in two landmark cases, in 1993 and 2004⁶⁰. The Court ruled in favor of the Governor as of his power to include changes in permanent law in his proposed appropriations bills. The State Finance Law is another element strengthening the position of the Governor in the budget process: its office is indeed in charge of managing the budget through administrative actions as the fiscal year unfolds. This puts the Governor at the center

⁵⁹ Which it has done repeatedly.

⁶⁰ 'New York State Bankers Association v. Wetzler' and 'Silver v. Pataki and Pataki v. The Legislature' respectively.

of the policy stage when mid-year budget gaps emerge, a critical feature for the realism of the model proposed in Chapter 4. By guaranteeing the prominence of a single decision maker for managing mid-year budget gaps, we may safely put aside group decision making as an additional layer of complexity in our mathematical programming framework.

Among the legislative branch considerable powers are vested in the leaders of each House over budget decisions. Effectively, the budget process is a negotiation between the governor, the Speaker of the Assembly and the Senate majority leader (Creelan and Molton, 2004). The legislature is thus not entirely powerless when facing the governor. At the height of the financial crisis in November 2008, when Governor Paterson called a special session to close a deficit of \$3.2 billion, the legislature remained inert and \$2.3 billion had to be carried away to the following fiscal year. Centralization is certainly reinforced by the lack of public debate, as amendments to the governor's budget are usually negotiated behind closed doors. It is not uncommon for the final budget proposition to reach members of the house just hours before the vote, and no independent body supervises a budget analysis.

The emergence of budget deficits have been made easier by the weakness of constitutional and regulatory constraints on budgeting decisions (Hou and Smith, 2006). The constitutional requirement that the governor submit a budget balancing general fund expenditures and receipts on a cash basis is relatively lax by national standards, and the budget passed by the legislature need not be balanced on either a

cash or an accrual basis⁶¹. Nor is there a requirement for the budget to be balanced at the end of the fiscal year, a technical provision that is be found in the literature to limit spending and budget deficits (Poterba, 1994; Alt and Lowry, 1994). So much that the Advisory Commission on Intergovernmental Relations (1987) attributed a score of 3 – one being the most lenient and ten the most stringent – to New York for the stringency of its balanced-budget requirements⁶².

3.4 Managing Structural and Cyclical Deficits

Perhaps the most striking feature of Albany’s management of budget deficits is its heavy reliance on one shot measures over long term policies (Ravitch, 2010). As a result, New York State made extensive use of debt to finance some of its past deficits⁶³. Successive governors and legislatures have also been prone to enact non-recurring spending cuts. Such gimmicks include the transfer of funds from one agency – the New York Dormitory Authority or the New York Power Authority being two of the traditional contendants – to the state’s general fund.

Despite the state’s long history of fiscal gimmicks, one-shot reductions of expenditures and mounting debt, numerous governors have taken the mantle of fiscal conservatism during their terms, from Republicans to Democrats. This is not

⁶¹ Actually, the Legislature is not constitutionally required to pass a budget.

⁶² New Jersey scored a perfect ten, which did not prevent its finances to suffer badly from the recession.

⁶³ The State Comptroller estimates that approximately 21% of the state’s debt outstanding can be directly attributed to fiscal relief.

particularly surprising from the perspective of political science, because voters tend to focus on the budgetary “bottom line”, i.e. whether a surplus or a deficit, as a proxy for the quality of an administration’s fiscal management (Savage, 1988). As such, the larger the move away from a balanced budget – in particular when talking about a deficit – the more likely the candidates are to focus on the budget issue. Moreover, research found that American voters are attached to the idea of a balance budget (Page and Shapiro, 1992). Voters’ view of the management of fiscal imbalances is however conditioned by the nature of the initial budget situation (Hansen, 1998). In the case of deficit, voters favor cutting discretionary spending over increasing income tax rates, while they favor increasing discretionary spending over reduced tax rates in the case of a surplus. This corresponds to the perspective of Nobel Prize winner Franco Modigliani, who also identified the electorate’s “antagonism to raising taxes as a way of reducing deficits” (Hansen, Modigliani and Modigliani, 1987:473).

Therefore, as Burden and Sanberg (2003:99) remarked, “the nature of [the voters’] preferences [...] is fairly predictable” and is “context dependent”. Fiscal retrenchment strategies are clearly favored when budget deficits becomes large enough. Given the structure of the Democratic Party constituency, the strategy adopted by Governor Paterson is somewhat surprising: beneficiaries from the Welfare State (middle-classes and low-income households) tend to affiliate with the Democratic Party while wealthier constituencies associate with the Republicans. In terms of policy, Democrats are usually perceived to focus on social spending and unemployment. The GOP, on the other hand, is associated with fiscal conservatism, austerity and inflation control

(Tuftes, 1978; Kiewiet, 1983). Then, candidates and incumbents tend to emphasize the aspects of the budget that are the most favorable to their own party, respecting a certain consistency over time (Hinich and Munger, 1994). This is unfavorable to Democrat candidate when there is a budget deficit, as public opinion leans toward austerity. In the case of the presidential election, Burden and Sanberg (2003) found that the volume of budget rhetoric emanating from the GOP is significantly increased when it is a challenger and when the budget is in deficit.

In this regard, the fiscally conservative postures adopted by Governors Paterson and Cuomo, two democrats with a relatively liberal background, may seem antithetic given their party affiliation but politically cunning. The two Governors championed budgets relying heavily on spending reductions to address fiscal imbalances and opposed major changes in the tax legislation. In fiscal 2009, the legislature intervened and significantly modified Governor Paterson's proposed budget and increased taxes and spending. This caused the Cato Institute (2010), a conservative think-tank, to attribute to Governor Paterson the worst grade possible, F, in its "Fiscal Policy Report Card on America's Governors"⁶⁴.

Despite these criticisms, the new budget emphasis brought by governors since the start of the Great Recession has been fiscal retrenchment. In Governor Paterson's own words (DoB, 2010:2):

⁶⁴ New York scored 25, half the average of the 45 states surveyed. Governor Paterson was ranked second to last, only topped by Ted Kulongoski from Oregon. Mark Sanford from South Carolina came first, with a score of 74.

“Since the day I became governor, I have warned that New York is facing an inevitable fiscal reckoning. The mistakes of the past – squandering surpluses, papering over deficits, relying on irresponsible fiscal gimmicks to finance unsustainable spending increases – have led us to a financial breaking point.

There are no more easy answers. Avoidance behavior is simply not acceptable. Federal stimulus funding is running dry. We have already increased taxes on high-income New Yorkers. And those who have doubted the severity of our financial difficulties were proven wrong time and time again.

Further spending reductions are both necessary and inescapable.

The Executive Budget I am proposing today continues the difficult process of confronting New York’s new fiscal reality. It attacks our substantial structural budget deficit through recurring spending reductions across every single area of State government. Given the gravity of the current situation, *there is simply no other option* if we want to end New York’s irresponsible pattern of boom and bust cycle budgeting”⁶⁵

In fiscal 2009, spending reductions proposed by Governor Paterson were concentrated in three program areas: education, the STAR program and Medicaid. We will come back in detail to this policy in chapter 5, as it provides the backbone of our social accounting matrix multiobjective linear programming model. Moreover, Albany has been wary about using the state’s rainy-day funds⁶⁶ to cushion the impact of the crisis.

⁶⁵ Our emphasis.

⁶⁶ New York State has two rainy day funds: the Tax Stabilization Reserve Fund, capped at 5% of the budget, and the Rainy Day Reserve Fund, capped at 3%.

Even though reserves constantly declined as a percentage of total expenditures between FY 2009 and FY 2012 (from 2.2% to 2.1%), the amount held, approximately \$1.2 billion did not vary. This can be explained by the length of the crisis and the uneasiness of the state legislature with using emergency ammo while the storm may still be coming. In the case of New York, it may also be argued that the replenishment rule it shares with five other states⁶⁷ and the District of Columbia makes it more difficult for Albany to tap in the funds when needed. The state is indeed required to replenish the funds in three years, even if economic conditions have not improved.

When a \$16 billion deficit appeared in the fiscal 2010 budget, balance was brought through ARRA funds amounting \$8 billion. The State did (temporarily) increase the tax rate on high-income individuals and raise tuition fees in public universities, but it also extensively used spending retrenchments, in particular by delaying payments to local governments. This reflects the experience of the state during the previous recession, in the early 2000s, when it enacted temporary increases in the income and sales taxes.

3.5 The Economy of New York State

With its diverse and broad industrial base, its qualified workforce and attractive business climate, New York State and New York City have developed resilient and adaptable economies. The state economy managed a relatively successful transition

⁶⁷ Alabama, Florida, Missouri, Rhode Island and South Carolina.

from a manufacturing- to a service-based economy, and recovered relatively quickly from the post 9/11 crisis (Bram, 2003). The economic success of New York State has much to do with the constant expansion of its human capital and the rapid development of a handful of extremely competitive industries, in particular finance and biotechnology. This is not to say that New York does not face many challenges, prominent among which is the economic crisis it entered in October 2008.

The structure of New York's economy and its socio-institutional characteristics, which we detailed in the following sections, responded differently to the economic crisis than the country as a whole. A certain number of sectors and indicators – for instance total nonfarm payroll employment – fared better, while others fared worse – for example the housing market.

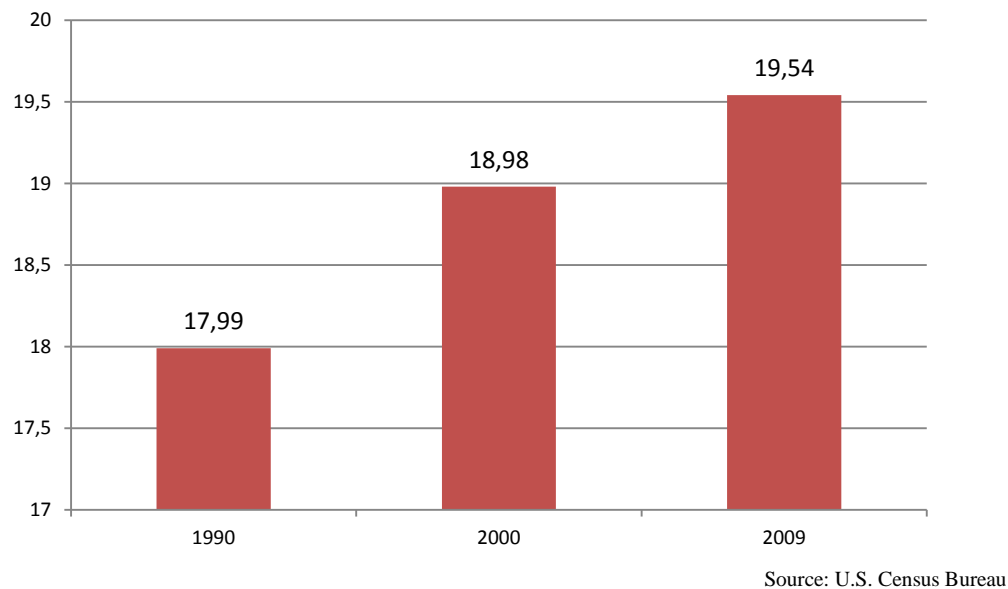
Historically, the fact that the economy of the “Empire State” performed better than the national average since 2000s is an exception. If New York dominated the economic landscape of the United States in the 19th century and in the first half of the 20th century, it did not share the post-World War II boom as much as other states did. From the onset of the Korean War to the burst of the internet bubble, New York State added jobs at a quarter of the national pace. The crisis was especially acute during the 1970s, a decade during which job creation in the state literally stopped. The picture brightened during the years of the Reagan administration, even if New York continued to lag behind the national averages for most statistics. The recession that started in early 1991 dealt a considerable blow to the already weakened state: with only 7% of

the population, it concentrated an astonishing 31% of all job losses from January 1991 to the election of Bill Clinton to the presidency. The Empire State barely did better in 2001, as its peak-to-trough period lasted 32 months.

3.5.1 Population and Employment

Contrarily to New York City, which population stagnated for most of the past 50 years at around 8 million, New York State displayed strong growth in the past decades.

Figure 3.21. New York State population (in millions)

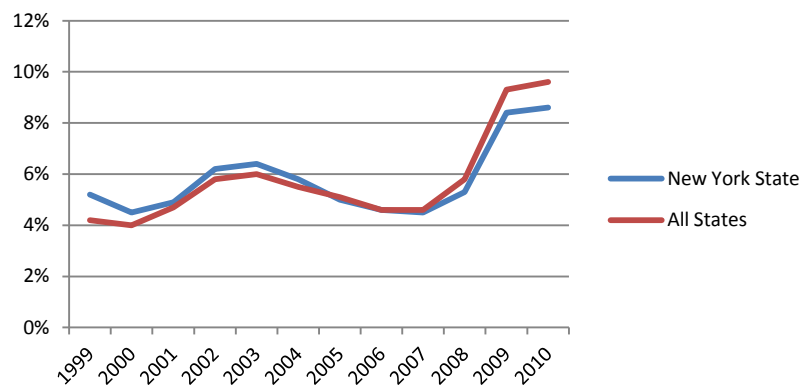


In 2007, New York State employed an average of 9,114,411 persons (BLS, 2011), implying that data from IMPLAN are overestimated⁶⁸. Even though its nonfarm payroll expanded at a slower pace than the national average for most of the past two

⁶⁸ Total employment is 10,690,700 in IMPLAN.

decades, New York State is still the third largest states in term of employment after Texas and California, at 6.5% of the total. The unemployment rate averaged 4.5% over the year, before the crisis took its toll on the payrolls.

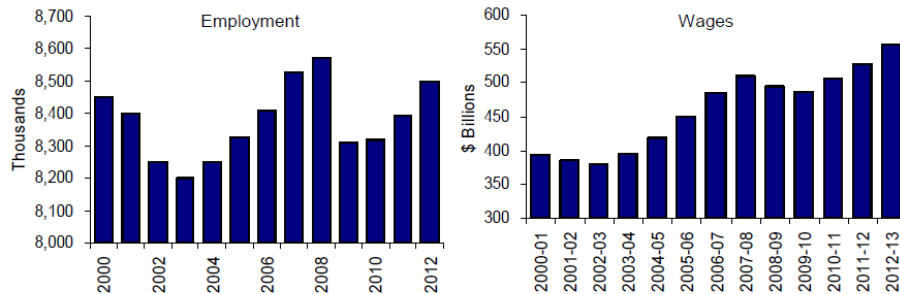
Figure 3.22. Unemployment rate in the United States and New York State



Source: Bureau of Labor Statistics

As we demonstrated, employment growth in New York State has been anemic in the 2000s and trailed national averages. New York's nonfarm employment growth lagged the national average for nineteen out of the past twenty years. Only in 2007, after the beginning of the recession and a significant downswing on the national job market did New York outperformed the country, a trend that was maintained up until the fall of 2010. Data suggests that New York had actually 343,000 jobs more than it would have if it trailed national averages (Ward, 2011).

Figure 3.23. Employment and wages in New York State



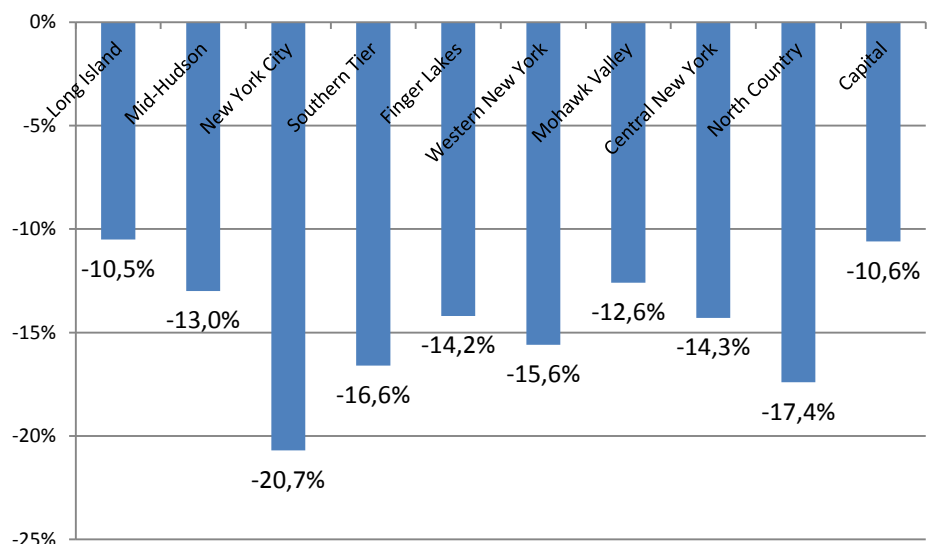
Note: Data for 2010 is estimated; 2011 and 2012 are forecasts. Employment levels are on a calendar year basis; wages are on a state fiscal year basis.

Source: NYS Assembly Ways and Means Committee

Employment losses have been heavily concentrated in the construction and manufacturing sectors. On the 250,000 jobs shed in the State between 2008:Q2 and 2010:Q1, 81,100 were in the manufacturing sector and 53,800 in the construction sector. The downswing in construction employment mirrored jobs destruction in other states, as construction of new houses took a hit with the subprime crisis. Losses were however smaller in New York State, as its housing market resisted better to the recession.

As for the manufacturing sector, it pursues its structural decline. Manufacturing jobs were destroyed at a faster rate in New York than in the nation as a whole and contracting by approximately 100,000 between 2007 and 2010.

Figure 3.24. New York State Manufacturing Employment by Region (2008:Q2 to 2010:Q1)



Note: United States average: -14.6%

Source: U.S. Department of Labor and NYS Department of Labor

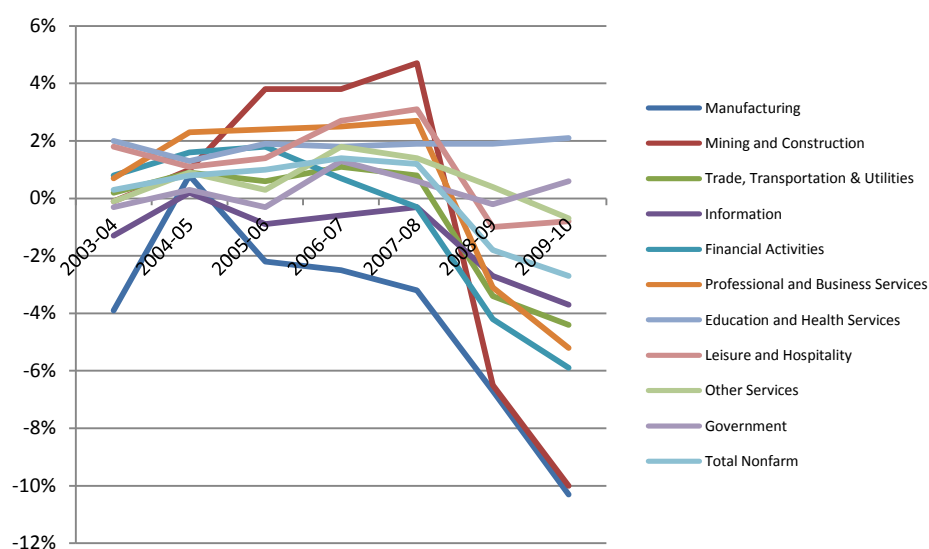
Losses in the financial sector were localized in New York City: the sole securities industry lost 9.7% of total employment in 2009 and 3.7% in 2010. In comparison, securities employment contracted by 7.9% nationally. All in all, the professional and business services sectors hemorrhage the most, along with trade, transportation and utilities. Together, they concentrated more than half of all jobs destruction in the state.

Employment figures for the public sector were mixed. The growth in public schools was important, with 9,000 jobs added between 2006 and 2010, but the state government virtually froze its payroll over the period (against +1.3% nationally).

On the positive side, the state continued to add jobs in the education and health care sectors, expanding by an average of 2% a year between 2008 and 2010. This must be contrasted however, inasmuch as job creation in health care and social assistance

lagged the national average. It is likely that limited demographic growth and increased fiscal pressure – hospitals and nursing homes are typically dependent on some forms of public funding – explain much of this slow pace. Leisure and hospitality also showed signs of dynamism as the weakening U.S. dollar attracted a growing number of tourists to New York City. Moreover, upstate New York, traditionally the poorest area in the state, suffered less from the downturn than New York City and directly adjacent areas did⁶⁹.

Figure 3.25. Job growth by sector in New York State



Source: Office of the State Comptroller

Total nonfarm payroll employment in New York State lost fewer jobs than the nation during the recession, which implies that recovery may trail the average for all states. For instance, the manufacturing sector shed 16.6% of its workers throughout the

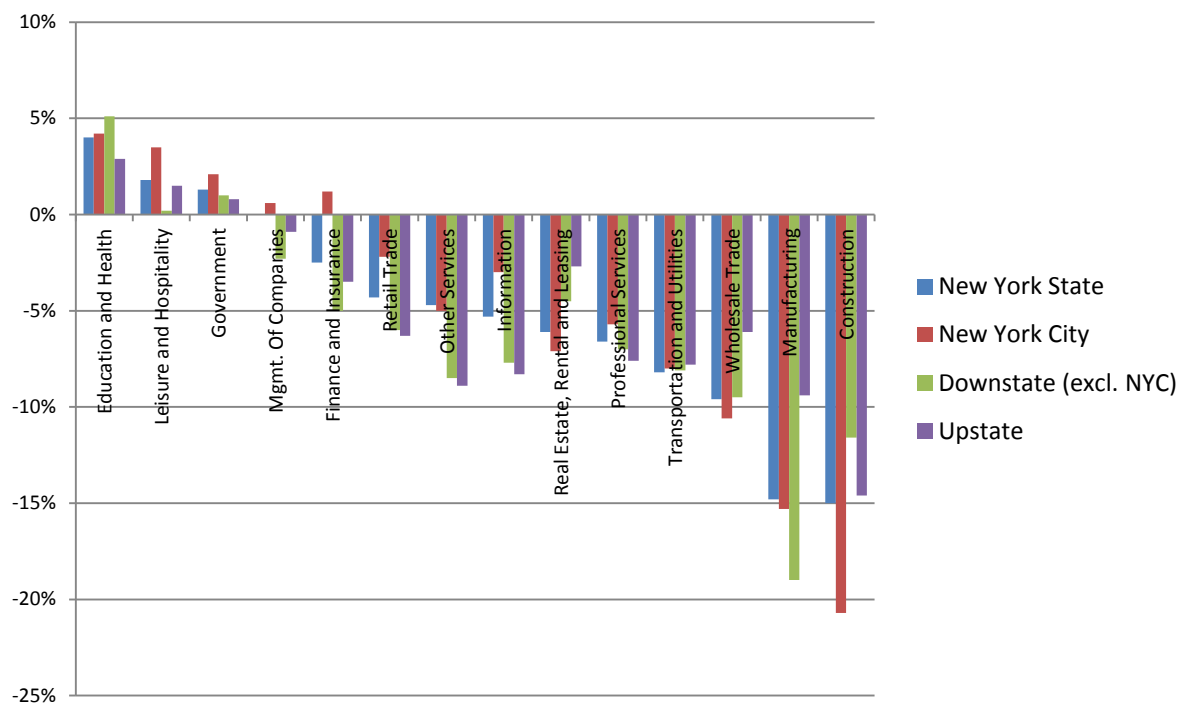
⁶⁹ However, New York City added far more jobs than upstate New York did during the boom years of the 2000s.

country between 2007 and 2010, against 15.5% in New York. Overall, it is estimated that New York State lost a yearly average of about 261,700 jobs from 2008 to 2009, or 3.1% of total nonfarm payroll. New York ranked eighth in terms of nonfarm payroll employment growth in 2009, after ranking thirteenth and twentieth in 2008 and 2007 respectively. The staff of the New York State Assembly Ways and Means Committee forecasts overall employment to grow by 0.9% in fiscal 2011 and 1.2% in fiscal 2012 after contracting by 3.1% and 0.1% in fiscal 2009 and 2010. The recovery should also boost total nonfarm wages, which declined by 7.2% in fiscal 2009, before picking up at the rate of 4.4% in 2010⁷⁰.

From a geographical perspective, the burden of employment decline appears to have been shared relatively evenly across the state.

⁷⁰ The variable wages, which are essentially driven by Wall Street's bonus took an unprecedented dive of nearly 31% in 2009, or \$21.6 billion.

Figure 3.26. Dynamic of New York State employment by region (2008:Q2 to 2010:Q1)



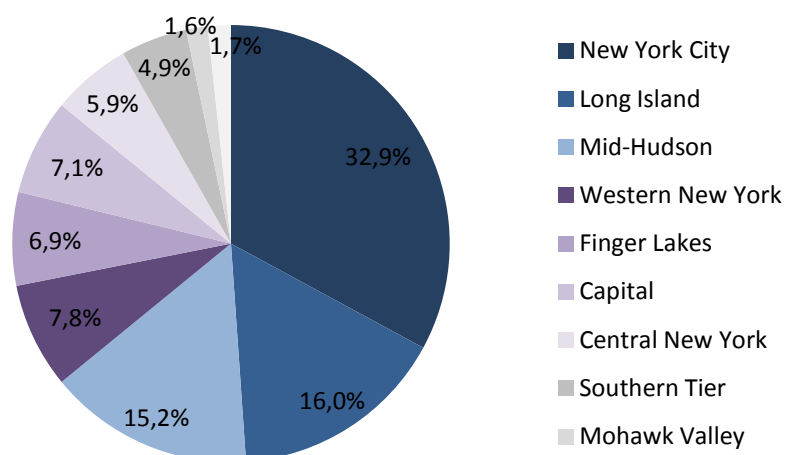
Source: NYS Department of Labor

Job attrition was the fastest in the Mid-Hudson and Central regions because of the hardship faced by the manufacturing sector, whereas New York City, with its large diversified economic base and its booming tourism sector remained the best performing area. An interesting fact is the second position of the Mohawk Valley, which enjoyed the 2008-09 government-led expansion in the education and health care sectors⁷¹. In terms of proportion, the dominance of New York City is illustrated by its 43.3% share of total nonfarm employment in the state. It also accounted for approximately 33% of job destruction. In comparison, Mid-Hudson concentrates a

⁷¹ These two sectors account for approximately half of total employment in the region.

little bit more than 10% of total nonfarm employment, and shouldered 15.2% of the state's employment losses.

Figure 3.27. New York State Nonfarm Employment by Region (2008:Q2 to 2010:Q1)



Note: Downstate New York concentrates 64.1% of nonfarm jobs, against 35.9% for Upstate

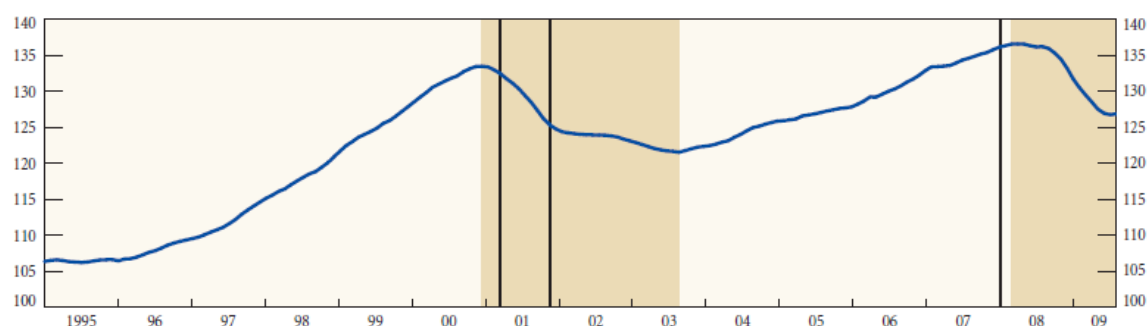
Source: NYS Department of Labor

3.5.2 The New York State Economy in the Great Recession

Although there is strong evidence suggesting that national and regional business cycles are not synchronized (Orr et al. 1999; Crone and Clayton-Matthews, 2005), there is little doubt that the intensity of the national financial and economic crisis that started in December 2007 caused severe damages to New York. Economic activity in the state, as captured by the Federal Reserve Bank of New York's coincident economic indicators (CEIs), peaked in February 2008. The deterioration of the economy accelerated significantly after October 2008. A particularity of the Great

Recession, when compared to previous economic crises in the late 1980s, early 1990s and 2000s is that New York State actually lagged the national peak of economic activity. In the late 1980s, Bram et al. (2009) remarked that the state experienced its downturn as soon as eighteen months earlier than the nation as a whole did. As we repeatedly noticed previously, the economic recovery in the New York metropolitan area also occur much later than for the U.S., lengthening the poor prospects for state government's revenues and spending.

Figure 3.28. Economic activity in New York State (base 100 = July 1992)



Note: The interval between the black vertical lines represent the peak-to-through periods of national business cycles. The shaded areas indicate the peak-to-through periods for New York State

Source: Federal Reserve Bank of New York

Unsurprisingly, economic data suggests that the economic downswing in New York State has been fuelled by unemployment, an element to which we dedicated a section previously.

3.5.3 Economic Structure and the Role of the Financial Sector

The data source of the model we develop in this dissertation is the Social Accounting Matrix for 2006 proposed by the Minnesota IMPLAN Group⁷². Given that only three years separate this data set from the policy under scrutiny, it can be argued that the economy of the state did not underwent tremendous structural transformations in such a brief period of time. In 2007, New York State's Gross Regional Product (GRP) amounted to \$1.022 trillion, or 7.6% of the United States GDP (\$13.2 trillion), the third largest in the country after that of California and Texas. The principal component of the state's economy was household consumption, which made up approximately 67% of its GRP. State and local governments represented the second largest component of final demand, with 15%. Federal government accounted for 2.6%, while demand for investment made up 9.1% of the GRP. Net exports amounted to 9%. The positive trade balance of \$92.3 billion illustrates the strength of New York in export-oriented activities, although the balance is lower than what it was during the Clinton years (vom Hofe, 2002).

The economic structure of New York State, as illustrated by the composition of its GRP, is heavily geared toward the tertiary sector and in particular the finance and insurance industries. In 2010, the state's economy expanded by a staggering 5.1%,

⁷² It is difficult to trace the sources used by MIG to develop its social accounting matrices. Although the data set we have refers to 2006, aggregate figures seem to correspond to 2007. For instance, the BEA estimates that the state's GRP for 2006 was \$1.001 trillion (in which case IMPLAN would grossly overestimate the economic size of New York State), but \$1.022 trillion in 2007, very close to IMPLAN's own results (\$117 million difference).

outperforming the Mideast region (3.8%) and the United States in general (2.6%)⁷³. According to preliminary data released by the Bureau of Economic Analysis (2011), the financial services industry alone contributed by nearly 35% (1.76 percentage point) to the state's real GRP growth, while the second largest contributor, the real estate, rental and leasing sector, only contributed 12.7% (0.65 percentage point)⁷⁴. By comparison, the United States' economic expansion relied primarily on durable-goods manufacturing and retail trade.

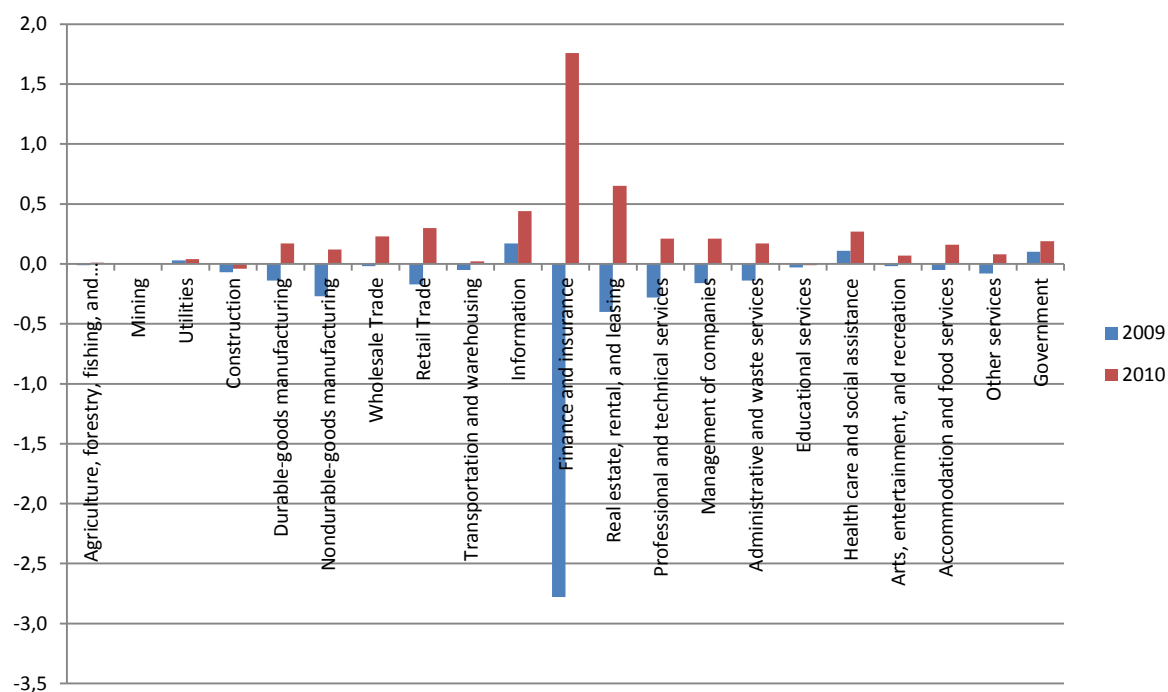
The central role of financial services in the economy of New York State is confirmed by the negative role it played in both 2008 and 2009. The adverse contribution of finance and insurance to the percentage change in real GRP during 2008 (-0.36 percentage point) was largest than the combined contribution of the second and third worst performing sectors, nondurable goods manufacturing (-0.18) and wholesale trade (-0.15) respectively. The trend is even more palpable at the height of the crisis, in 2009, when the economy of New York contracted by 4.3%⁷⁵. Finance and insurance contributed for 2.78 percentage point to this poor performance, far more than all the other sectors combined (-1.89 percentage point).

⁷³ New York indeed ranked in the highest quintile.

⁷⁴ The finance and insurance sector was the largest contributor to growth in the Mideast region in 2009, and topped every other industry in Delaware and New York, coming close second in the District of Columbia and fourth in New Jersey.

⁷⁵ Against 2.1% for the country as a whole. New York was ranked in the lowest quintile.

Figure 3.29. Contributions to percent change in real GRP (in percentage points)



Source: Bureau of Economic Analysis

On a static basis and using a 35-industries aggregation scheme for the social accounting matrix close to the NAICS classification, the importance of the financial services sector is confirmed. ‘Finance and Insurance’ had by far the largest output, with \$229.6 billion (22.5% of commodity production), outstripping ‘Wholesale and Retail Trade’ (\$160.9 billion) and ‘Real Estate, Rental and Leasing’ (\$111.9 billion). The value of production is also particularly high in finance and insurance, reaching \$323,523 per worker against \$213,157 as a national average. If the sector accounted for 6% of total nonfarm payroll employment in 2009, it concentrated approximately 20% of total nonfarm payroll wages.

The concentration of the industry in New York City makes the downstate area especially sensitive to the health of the finance and insurance sector. Finance and insurance variable compensation collapsed by 42.5% in fiscal 2008, or \$24.7 billion.

3.5.4 The State and Local Government Sector

Of particular interest to this dissertation is the state and local government sector. In terms of output, the size of the sector is relatively limited, at \$81.2 billion (7.9% of total output). The breakdown of this sector is as follow:

- \$58.5 billion for State and Local Non-education
- \$40.4 billion for State and Local education

Its role in aggregated consumption is more consequential. According to IMPLAN's data, local commodity demand for state and local non-education (\$63.2 billion against \$19 billion for the Federal government), state and local education (\$45.4 billion) and capital expenditure (\$19.4 billion) amounted to \$127.98 billion.

The importance of state and local government in the economy of New York State is however better reflected by employment statistics. The top employer in the state was 'Wholesale and Retail Trade', with a headcount of 1,419,750 employees (13.3%). State and local governments followed with 1,307,330 people (12.2%), nearly twice as many persons employed than in the finance and insurance sector. Total employee compensation however significantly lagged the 'Finance and Insurance' sector (\$114.6 billion) and the 'Professional, Scientific and Technical Services' sector (\$58.3 billion).

It amounted to \$44.2 billion in state and local non-education and \$37 billion in education, respectively ranked #3 and #4. If combined, the two sectors would overtake ‘Professional, Scientific and Technical Services’ as the second largest sector for employee compensation.

In terms of Type SAM multipliers, state and local government do not seem to perform as well. On 36 sectors, ‘State and Local Education’ ranks 34th with an employee compensation multiplier of 1.26. State and Local Non-education fares marginally better, ranking 33th with a multiplier of 1.32 (the average is 1.92). Turning our attention to employment multipliers, perhaps more important, we can observe that the state and local government sectors do not perform better (education ranks 34th, with a multiplier of 1.3 while non-education ranks 25th, with a multiplier of 1.51). This is far from top performing sectors, such as ‘Pharmaceuticals’ (5.92), ‘Computer’ (5.1) or ‘Finance and Insurance’ (2.78). As for the federal government, it ranks 21st. Finally, as far as labor income multipliers are concerned, state and local governments again perform relatively disappointingly (rank 33 and 34 for non-education and education respectively). This is however not necessarily bad news in our research context. Indeed, budget cuts translating into a negative shock on the final demand vector of the SAM framework, small multipliers will actually translate into bottlenecks limiting the destructive impact of fiscal retrenchment on the economy.

CONCLUSION

The economy of New York State has suffered a great deal since 2007. It however fared better than other states in these tumultuous times, and even outperformed national averages for the first time since World War II. The reason why it is so is still unclear. The absence of a real estate bubble in New York may partly explain why employment suffered less in the Empire State although foreclosure on mortgage loans was pervasive, at least in 2009. The strong support of Washington to the financial sector in general and to Wall Street in particular is also a factor to consider, as it probably saved many high-paying jobs in New-York City's Financial District and the indirect employment they create.

It is difficult to find structural causes to this comparatively good performance. State taxes, a permanent source of parliamentary feuds in Albany, remain high by national standards, and were even hiked during the crisis. The environmental standards tend also to be stricter than in other states, while energy costs are higher.

No matter the reasons behind this performance, the short episode of economic 'exceptionalism' New York State enjoyed is expected to come to a halt in 2011, with employment in the private sector reverting back to its long-term trend. This is especially worrisome in light of the past. It is indeed estimated that the consistent under-performance of the state since the 1950s has cost it nearly 10 million jobs, or an annual average of 200,000 (Ward, 2009). This leads us to believe that the budget of New York State may not stabilize before a strong recovery takes place in the United

States. Given the current economic climate in the U.S. and strong uncertainties in Europe, Albany is still in a position where it would need additional rounds of fiscal retrenchments to manage budget shortfalls.

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Chapter IV

GENERAL FRAMEWORK FOR A SOCIAL ACCOUNTING MATRIX MULTIOBJECTIVE LINEAR PROGRAMMING MODEL

This chapter provides an overview of the two analytical research tools on which this dissertation is based: social accounting matrix (SAM) and multiobjective optimization (MOO). These two methods are then combined into a single model illustrating how it can be used to help decision makers solving the problems they are facing in an optimal, given various policy instruments and conflicting objectives.

4.1 The Social Accounting Matrix Framework

4.1.1 The Input-Output Model

The mathematical structure of a Social Accounting Matrix (SAM) is directly derived from the Input-Output system it expands: a set of n linear equations with n unknowns that describes the distribution of industries' output throughout the economy. In this respect, a social accounting matrix can be likened to a double entry bookkeeping

framework offering a static image of an economy. It is structured around a set of accounts that record income and expenditure⁷⁶ and that must balance. This balancing condition implies that each sector/institution's income is another sector/institution's expenditure, thus forming a circular flow capturing all transactions and transfers in an economy. At the microeconomic level, SAM describes the economic activity of each agent in the economy while after aggregation it forms a macroeconomic model. The level of aggregation varies with the topic at hand. Agents included in a *typical* SAM⁷⁷ are divided between endogenous and exogenous accounts, the latter incorporating industries, factors of production (land, labor and capital), households and corporations while the former usually gathers government, capital and the rest of the world. The division between exogenous and endogenous accounts derives from the use of SAM as an impact analysis tool.

From a computational standpoint, the system can be expressed using square matrices, which makes it easier to manipulate and relatively straight-forward to solve. By convention, each cell in the SAM matrix represents a spending flow⁷⁸ from the column account to the row account. Row accounts record agents' sources of income. SAM thus appears to constitute a generalization of the System of National Account (SNA), the international standard to compile measures of economic activities developed by the United Nations. SAM enriches the SNA framework by offering a detailed view of the

⁷⁶ In general, accounts present incomings and outgoings.

⁷⁷ Various forms of SAM exist, in particular the Commodity-by-Industry approach (for a description, see Eurostat, 2008).

⁷⁸ Originally, Leontief developed an input-output model based on physical quantities (Leontief, 1951). Nowadays, price and mixed-units models are more common

transactions and transfers between institutions involved in the (re)distribution of income in the economy. This feature is what distinguishes a social accounting matrix from an input-output model (Round, 2003). Originally, the framework was indeed created to investigate developmental issues and in particular the impact of policy on living standards. While growth in output certainly contributes to the improvement of living standards, economists quickly acknowledged that the distribution of income among groups also constituted a critical area of study for development economics. Unsurprisingly then, the first SAMs were created for two developing economies: Iran and Sri Lanka in 1970, and Swaziland a year later (Pyatt and Round, 1985).

Table 4.1. A Social Accounting Matrix Transactions Table

				Expenditures						
				Endogenous Accounts			Exogenous Accounts			Total
				Production	Factors	Households	Government	Savings and investment	Rest of the world	Total output
				1	2	3	4	5	6	
Income	Endogenous Accounts	Production	1	Intermediate input		Consumption spending	Recurrent spending	Investment demand	Export earnings	Total demand
		Factors	2	Factors requirements						Total factor income
		Households	3		Factors payment to households	Income transfers	Social transfers		Foreign remittances	Total household income
	Exogenous Accounts	Government	4	Sales taxes and import tariffs		Direct taxes			Foreign grants and loans	Government income
		Savings and investment	5			Private savings	Fiscal surplus		Current account balance	Total savings
		Rest of the world	6	Import payments						Foreign exchange outflow
	Total	Total outlays	7	Gross output	Total factor spending	Total household spending	Government expenditure	Total investment spending	Foreign exchange inflow	

Source: Adapted from Breisinger et al. (2010)

In itself, the social accounting matrix does not constitute an economic model but simply a database support for models of national income and expenditure. The initial application of the SAM framework to policy analysis was in the form of multiplier models, a straightforward extension of the input-output logic.

4.1.2 The Social Accounting Matrix Multipliers

The benefits of the SAM framework have much to do with the multipliers that can be derived from it. Multipliers are particularly useful for economic planning purposes because they allow computing the direct and indirect effects of a given economic shock on macroeconomic variables, reflecting the linkages and interdependences existing between institutions in an economy. As Burfisher (2011:68) puts it, “multiplier models essentially trace the effects of an exogenous shock in one or more parts of the SAM throughout the rest of the SAM as an accounting procedure. Producers adjust the quantity of their output to meet any changes in demand and consumers adjust their demand in response to any changes in income”.

At the center of the multipliers model is the Input-Output analytical framework originally developed by Wassily Leontief in the late 1930s. Using data recording inter-industry flows in monetary terms in a particular economy over a defined period of time – usually a year – it is possible to create a **table of transactions** between pairs of industries. The input-output model thus concentrates on inter-industry production linkages. Cells in the transaction table are algebraically represented by the notation z_{ij} ,

where j designates the demand for inputs from other sectors while i denotes the sector from which inputs originate. The inter-industry table is completed by a set of additional columns, **final demand**, which records the sales by each industry to final markets, usually consumers, investment, the government and exports. Because demand emanating from these markets is assumed to be determined by factors other than amounts being produced by each industry, they may theoretically be considered exogenous. The determination of exogenous sectors is a critical step for the computation of multipliers. Indeed, without exogenous sectors, the Walras Law teaches us that the matrix of input-output coefficients cannot be inverted. Finally, additional rows are used to determine **value added**, i.e. non-industrial inputs used by industries for production. This includes accounts such as employee compensation, depreciation of capital, indirect business taxes and imports.

In an Input-Output model, total production for each industry composing the economy of interest may be expressed as a function of the sale of its production across all other sectors and final demand. If x_i is the total output produced by industry i over a year, and f_i denotes the aggregated final demand for this industry's output, then in a n sectors economy we will have:

$$x_i = \sum_{j=1}^n z_{ij} + f_i$$

As noted earlier, this can be expressed in a more compact form thanks to matrix notation:

$$x = Zi + f$$

where x is the $n \times 1$ column vector of total output, Z_i is the matrix of inter-industry sales and value added and f is the $n \times 1$ column vector of final demand.

Because this study aims at analyzing the impact of budget cuts on the economy of New York State, the column vector of final demand f should be disaggregated further to accommodate the variety of components that together form final demand, such that:

$$f = c + i + f_g + s_g + l_g + e$$

where c represents consumer demand, i purchases for private investment purposes, f_g the federal government demand, s_g the state government demand, l_g the local governments demand and e the demand from abroad (exports).

The same applies to the payment sector, which gathers imports and value added. Indeed, besides employee compensation industries must also use a variety of government services along with other inputs (land rent, interest payment to capital...) and imports to produce outputs. It is therefore possible to disaggregate further this sector into several rows:

$$v = l + fgs + sgs + lgs + n + m$$

where l represents employee compensation, fgs , sgs and lgs government services for the federal, state and local government services respectively, n other value added elements (rents, payment to capital) and m imports. Certain cells located at the intersection of the value added rows and final demand columns are of particular importance for this study, as they include tax payments (row n /column c) and

employee compensation for civil servants and government workers (row l /column $fg;sg;lg$).

In the simplified model just presented, total gross output X for the entire economy may be expressed as:

$$X = \sum_{i=1}^n x_i + v + m$$

The sum of outputs produced by each industry, value added and imports. By construction, the total sum of rows and columns must be equal in an Input-Output model: total gross output equals total gross outlays, the latter being expressed such that:

$$X = \sum_{i=1}^n x_i + c + i + g + e$$

In other words, gross national income is set to equal gross national product.

The next step in the creation of a full-fledged Social Accounting Matrix model is to compute the matrix of technical coefficients based on the inter-industry transactions table. Each coefficient for sector j , denoted by a_{ij} , is computed as the monetary value of inputs from industry i it uses in its production process divided by the total monetary value of its production, or:

$$a_{ij} = \frac{z_{ij}}{x_i}$$

The way technical coefficients are computed in the SAM thus implies that every sector in the economy is subject to constant returns to scale. Factors of productions, including industrial inputs, value added components (land, capital, labor and government services) and imports are used in technologically pre-determined fixed proportions, and factors are not substitutable. Industries behave according to a production function known as the Leontief production function, a special case of the constant elasticity of substitution production function:

$$x_j = \min \left(\frac{z_{1j}}{a_{1j}}, \frac{z_{2j}}{a_{2j}}, \dots, \frac{z_{nj}}{a_{nj}} \right)$$

This assumption of constant returns to scale is all the more important in regard of our ulterior use of a linear programming model and guarantees that the proportionality assumption about both the objective function and the functional constraints is not violated. Having established the fixed character of technical coefficient, equation (1) can be re-written as:

$$x_i = \sum_{i=1}^n a_{ij}x_i + f_i$$

In matrix form, this would translate as:

$$x = Ax + f$$

Because final demand f_i is exogenously determined and the technical coefficients are derived from data⁷⁹, it is possible to determine the amount of output from each sector necessary to accommodate a shock in final demand: this is the very purpose of input-output analysis. Formulating a new set of equations such that the parameters and the endogenous variable are placed on the left-hand side and the exogenous variable on the right-hand side, we have:

$$x_i - \sum_{i=1}^n a_{ij}x_i = f_i$$

The Input-Output system of n linear equations can be formulated in matrix notation as:

$$(I - A)x = f$$

where I is a $n \times n$ identity matrix and A the technical coefficients matrix. The unique solution to the system, if it exists, is found by using the total requirements matrix, which is simply the inverse of $(I-A)$. This implies that:

$$x = (I - A)^{-1}f$$

Assuming that technology does not change⁸⁰, and this is the case with a Leontief production function, the total requirements matrix $(I-A)^{-1}$ can be considered a parameter. In terms of change, it is therefore possible to find the general equilibrium impact of an exogenous shock on the economic system with the following equation:

$$\Delta x = (I - A)^{-1}\Delta f$$

⁷⁹ They are thus considered parameters in the model.

⁸⁰ Technology is represented by the A matrix.

This final equation, perhaps the most important in input-output analysis, enables the computation of a sum of consecutive rounds of adjustment to an exogenous demand-side shock until the economy settles down again in a state of general equilibrium. Demand-side shock usually refers to changes in government spending, the demand of foreign countries for domestic products (exports) or investment demand.

4.1.3 Modeling Exogenous Shocks: Final Demand and Total Output Vectors

Exogenous shocks in the social accounting matrix are modeled through a final demand column vector that reflects the research question investigated. The general equilibrium impact computations indeed do not uniquely depend on the figure associated to each element of the final demand vector, but also on the closure of the model, i.e. which sectors the researcher chooses to endogenize. Most commonly, sectors such as the government, the capital account and the rest of the world are rendered exogenous⁸¹.

Thanks to the multipliers underlying it, social accounting matrices are able to model effectively the linkages existing between an economy's structure (the inter-industry sub-matrix) and the distribution of income across economic agents, and primordially households. The introduction of the exogenous shock vector, along with a column

⁸¹ In the case of an input-output model, it is also usual to see the households account as an exogenous sector.

vector of total output change Δx , offers the possibility of carrying out comparative static analysis, a useful feature for policy and economic planning.

The column vector Δx , which captures the economic impact of the demand shock, summarizes three different types of effects:

- The direct effects pertain to the sector directly affected by the exogenous shock
- The indirect effects pertain to the repercussion of a change in a sector's demand for intermediate goods and services
- The induced effects pertain to the change in demand from households resulting from the income they derive from economic activity

Mathematically, to each effect is attached a particular multiplier that can be found through decomposition. M_1 , the matrix of direct effect⁸² multipliers is:

$$M_1 = \begin{bmatrix} (I - A) & 0 \\ 0 & I \end{bmatrix}^{-1}$$

The matrix M_2 of indirect multipliers⁸³ is:

$$M_2 = \begin{bmatrix} I & (I - A)^{-1}C \\ H & I \end{bmatrix}$$

where H is the matrix of coefficients allocating household income to value-added categories and C is the matrix of endogenous final consumption coefficients.

Finally, the induced (or feedback) effects are captured by M_3 , the matrix of “closed loop” multipliers:

⁸² Also referred to as “intragroup” or “own” multipliers.

⁸³ Or “extragroup” or “open loop” multipliers.

$$M_3 = \begin{bmatrix} [I - (I - A)^{-1}CH]^{-1} & 0 \\ 0 & [I - H(I - A)^{-1}C]^{-1} \end{bmatrix}$$

The magnitude of the multipliers is determined by the strength of backward and forward linkages in the economy. Backward linkages refer to the change in demand for intermediate input of sectors affected by the exogenous shock while forward linkages refer to the adjustment of the production of sectors downstream of where production was initially stimulated. Moreover, because SAM multipliers incorporate both consumption linkages and production linkages, they tend to be larger than input-output multipliers. Indeed, input-output multipliers focus uniquely on production linkages, ignoring the impact caused by additional incomes to households⁸⁴ generated by the change in production.

SAM thus reveals itself as a more complete approach to mapping the circular flow of spending and revenue in the economy, and offers an interesting tool to translate exogenous demand shocks into changes in endogenous macroeconomic variables, including gross output, labor income and employment.

⁸⁴ Income also accrues to factors of production, but in the SAM framework, it is assumed that households are the ultimate owners of the factors of production, be it land, capital or labor.

4.1.4 Assumptions, Limits and Appropriateness of the SAM Framework

If SAM enjoys certain advantages over input-output models, it suffers from the same limitations. Indeed, using SAM to model an economy implies defending strong assumptions:

- the behavior of firms can be represented by a linear production function with constant returns to scale (the so-called Leontief production function);
- the model is demand-driven, and there are no supply constraints on the goods and services market and on the market for factors of production;
- prices are exogenous, and thus fixed.

SAM is also a static model in nature. Furthermore, by using a SAM framework we make the assumption that the fiscal multiplier of state spending is at least equal or superior to one. This implies that by construction, the model cannot converge toward so-called “expansionary contraction”, i.e. an above-trend output growth accompanying a fall in the cyclically adjusted budget deficit. We believe that at least in the short-run – the timeframe that is of interest to us here – there is few empirical evidences suggesting that slashing spending lead to higher aggregate output: the examples of Greece, Ireland and the United Kingdom appear edifying in the case of the 2008 financial crisis (The Economist, 2011). More concerning perhaps is the magnitude by which the fiscal multiplier deviates from one. If the multiplier is indeed very close to one in the case of New York, then the exercise lose somewhat of its interest: slashing expenditures would certainly have a depressive effect on the local economy, but it

would not ripple throughout the production sector and magnify losses in employment and output. We would thus be relatively indifferent among cutback management strategies. The question of the size of fiscal multipliers has been central in macroeconomics, but research on the topic at the local level is scarce. At the national level, Blanchard and Perotti (2002) find a fiscal multiplier of 1.1 for government spending in the U.S. while Dalsgaard *et al.* (2001) find 2.1. Perotti (2005) estimates it to be 2.2. Because the economy of the state of New York is more open than the one of the United States, we would expect its fiscal multiplier to be somewhat smaller⁸⁵. Serrato and Wingender (2010) find that federal spending has a local income multiplier of 1.88 and a certain number of papers recently demonstrated that the income multiplier may actually get larger during episodes of recession (Christiano et al., 2009; Auerbach and Gorodnichenko, 2010; Woodford, 2010). Thus, our assumption of a significantly larger than one fiscal multiplier appears comforted by recent empirical works. Besides, because SAM is a static general equilibrium model, the resulting change in output from an exogenous demand shock will likely be far larger than the one that can be observed through econometrics model.

Using SAM for fiscal policy analysis is not without appeal, in particular for this dissertation. Capturing the impact of budget retrenchment on the economy of New York State requires a comprehensive and consistent disaggregated general equilibrium data system offering both a model of the State's socioeconomic system and a set of

⁸⁵ This may however well depend on the nature of the spending of both levels of government. If state expenditures result in higher aggregate demand – perhaps because their spending is more targeted and efficient – then we could imagine the local fiscal multiplier to be larger than the federal.

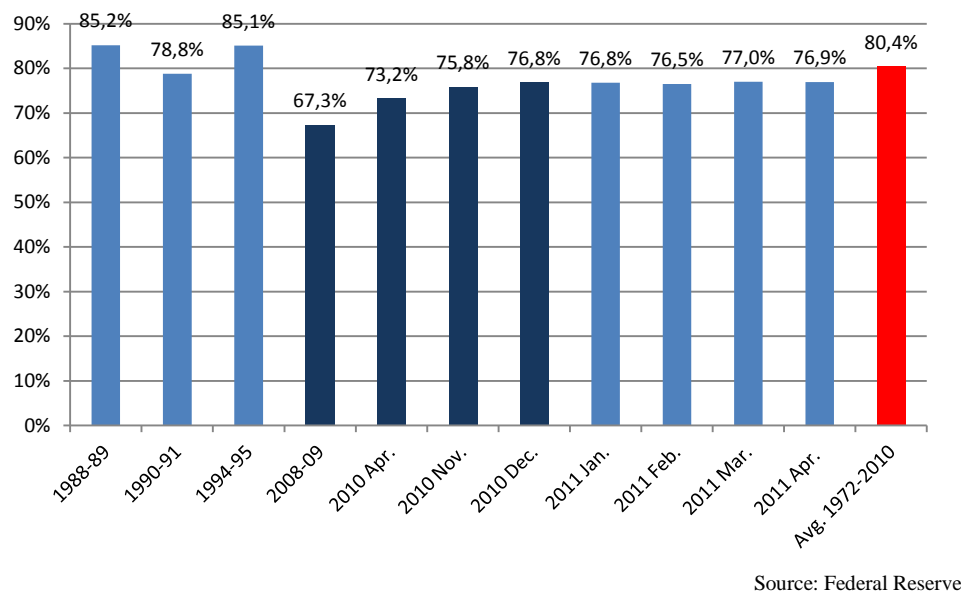
initial values for exogenous and endogenous variables. SAM answers precisely these two requirements (Thorbecke, 1988). As for SAM in our proposed social accounting matrix multiobjective linear programming model, it provides:

- a consistent structural framework allowing to compute the general equilibrium of the economy and the associated values taken by target variables (i.e. objective functions) corresponding to various settings of policy instruments;
- A database to assign specific values to the C matrix of parameters in the linear program.

Another advantage of the SAM framework is that it is sufficiently flexible to allow “fine-tuning” for particular issues. How disaggregated and large the matrix must be depends on the amount of data available to the researcher and the motivation behind the research project. The closure of the matrix is another sphere of flexibility: depending on the research objectives, one can choose to render exogenous (or endogenous) given sectors or sub-components of them. In this regard, the strength of the social accounting matrix framework resides in its endogenization of households, making possible the study of the distributional effect of policies. SAM thus constitutes a convenient type of general equilibrium model, simpler to manipulate and solve than the more cumbersome CGE models. This feature is attractive for our study, because the general equilibrium model must actually be combined with an optimization program.

The focus of the research being on mid-year budget cuts, it appears relatively realistic to postulate that in the short term agents in the production sector can be represented by a Leontief production function. In the same fashion, sticky prices are not a major violation of either economic theory or empiric studies in the short run. The logic of using a demand-driven model appears solid in the case of the United States and New York State, two economies where consumption is the main driver of economic growth and employment. Furthermore, the demand-driven characteristic of the model is, we believe, especially appealing to approximate an economy in crisis. The absence of supply constraints does not appear problematic in the case of the United States, where significant production capacity remained unused during fiscal year 2010.

Figure 4.1. Capacity utilization in the United States



Having justified our preference for social accounting matrices in the framework of this dissertation, we must however point out to certain weaknesses of our treatment of the

methods in the subsequent pages. Social accounting matrices require a vast amount of data to be constructed and the building process is both time-consuming and tricky. We thus rely on the Minnesota IMPLAN Group for our New York State SAM, which poses some difficulties. The most prominent is the impossibility to fine-tune the SAM to our needs. In particular, the level of aggregation of the sector of interest to us, state and local governments, is too high, clearly reflecting the necessity for economists to actually build their own SAM to study questions that span beyond the impact analysis of small projects.

4.2 Aspects of Multiobjective Linear Programming

Now that we have established a model to evaluate the impact of a policy on the economy, we may turn our attention to the method through which said policy can be optimized. In the introduction, we observed that policy makers must usually respond to multiple conflicting objectives, in which case the classical linear programming approach proved flawed and simplistic. On the contrary, multiobjective linear programming enables a systematic and simultaneous optimization of a collection of objective functions, circumventing the difficulty of modeling preferences through a single criterion or utility function.

Definition 4.1. An objective function is a mathematical function of some decision variables providing the decision maker with an appropriate measure of performance

Definition 4.2. The decision variables, gathered in a vector \vec{x} , are modified to perform a search for an optimum of the objective function

Besides engineering, the most important field of application for multiobjective linear programming (MOLP) has been operations research and finance, with extensive works realized in capital budgeting decisions, project evaluation and portfolio optimization to quote but a few (Steuer et al., 1996). The technique however originated in microeconomics and matured along the development of the welfare and utility theory (Stigler, 1950).

In this section, we present the basic elements and concepts of multiobjective linear programming (MOLP) and an application of the technique to a policy problem with economic and equity objectives. Sub-section 4.2.1. presents multiobjective programming in comparison of the classical single objective linear programming model, while sub-section 4.2.2. elaborates on the most critical concepts necessary to the understanding of MOLP.

4.2.1 From Monobjective to Multiobjective Programming

The most common type of application for linear programming involves the allocation of limited resources among competing activities in an optimal way (Hillier and Lieberman, 1995). The objective of the problem, denoted Z , is mathematically

captured by an overall measure of performance, or criterion, through the introduction of an objective function $f: X \rightarrow R^1$ where R^1 denotes a one-dimensional Euclidean space. The value of $f(x)=Z$ indicates how much impact is given on objective Z by performing an alternative x (Sawaragi et al., 1985). A standard form of a minimization monobjective linear problem can thus be formulated as follow:

$$\begin{aligned} & \text{Minimize} && f(\vec{x}) \\ & \text{subject to} && \vec{g}(\vec{x}) \leq 0 && (m \text{ inequality constraints}) \\ & \text{and} && \vec{h}(\vec{x}) = 0 && (e \text{ equality constraints}) \\ & \text{with } \vec{x} \in \mathbb{R}^n, \vec{g}(\vec{x}) \in \mathbb{R}^m \text{ and } \vec{h}(\vec{x}) \in \mathbb{R}^e \end{aligned}$$

where $f(\vec{x})$ represents the objective function to optimize, while $\vec{g}(\vec{x})$ and $\vec{h}(\vec{x})$ correspond to vectors of inequality and equality constraints respectively. The decision variables, exogenous to the model, are gathered in the vector \vec{x} . The search for an optimal solution is done by modifying this vector. Note that a vector \vec{x} in \mathbb{R}^n is written as a row vector but when using matrix calculations it will take the form of a column vector of dimension $n \times 1$.

The multiobjective counterpart to this model takes the form:

$$\begin{aligned} & \text{Minimize} && \vec{f}(\vec{x}) \\ & \text{subject to} && \vec{g}_j(\vec{x}) \leq 0 && j = 1, 2, \dots, m \\ & \text{and} && \vec{h}_l(\vec{x}) = 0 && l = 1, 2, \dots, e \\ & \text{with } \vec{x} \in \mathbb{R}^n, \vec{f}(\vec{x}) \in \mathbb{R}^k, \vec{g}(\vec{x}) \in \mathbb{R}^m \text{ and } \vec{h}(\vec{x}) \in \mathbb{R}^e \end{aligned}$$

where we have $k \geq 2$ objective functions are gathered in the \vec{f} vector.

In order to spare ourselves cumbersome notations, we will henceforth eliminate the vector superscript. The purpose of a multiobjective optimization is to minimize or maximize “at best” the various objective functions. We know from our initial set of equations that $\vec{x} \in R^n$ is the vector of decision variables, where there are n (independent) decision variables x_i . $\vec{f}(\vec{x}) \in R^k$ is the vector of objective functions $\vec{f}_i(\vec{x}): R^n \rightarrow R^1$. The gradient of $\vec{f}_i(\vec{x})$ with respect to x is $\nabla_x \vec{f}_i(\vec{x}) \in R^n$. The significance of the gradient is that the infinitesimal change in x that maximizes the rate at which $f(x)$ decreases is the change that is proportional to $\nabla f(x)$ (Hillier and Lieberman, 1995).

The general multiobjective optimization problem can be re-written as⁸⁶:

$$\begin{array}{ll} \text{Minimize} & f(x) = [f_1(x), f_2(x), \dots, f_k(x)]^T \\ \text{over} & x \in S \end{array}$$

where the decision variable vector x belongs to the nonempty feasible region S , itself a subset of the decision variable space R^n . S is defined as a set such that :

$$\{x | g_j(x) \leq 0, j = 1, 2, \dots, m; \text{ and } h_l(x) = 0, l = 1, 2, \dots, e\}$$

As for the feasible criterion (or objective) space, denoted Z , it is the set:

$$\{f(x) | x \in S\}$$

⁸⁶ Certain authors replace the “Min” or “Max” element by “Eff”, implying that the multioptimization program actually searches for a set of Pareto efficient solutions to an optimizing problem.

From this formulation derives an interesting particularity of multiobjective linear programming over monobjective programming: if the latter focuses on the decision variable space, the attention of the analyst often shifts to the objective space – usually of lower dimension – in the case of the former. Using a two-dimension graphical representation, this implies that the axes in a single objective linear programming problem will be (x_1, x_2) , the decision variables, while they will be (f_1, f_2) , the objective functions, for MOLP.

4.2.2. Concepts

Throughout the rest of the dissertation, a certain number of critical concepts will be mobilized repeatedly. This sub-section is dedicated to clarify their meanings. As a tool helping decision makers to ameliorate their choices, multiobjective linear programming is constantly addressing the issue of defining the preferences of the decision maker. The exercise is particularly difficult because contrarily to monobjective programming, the objective space in MOLP problems is only partially ordered. In other words, it is extremely difficult to compare vectors in real space (Chankong and Haimes, 1983), and this challenge is considered the trickiest part in implementing MOLP (Steuer, 1986).

Definition 4.3. Preferences pertain to the decision maker's opinion vis-à-vis points in the objective space, and are represented in a preference function ideally under the form of a mathematical utility (or preference-preserving) function.

If single-objective optimization reaches clearly defined solutions, it is not the case of multi-objective linear programming. The method indeed aims at finding a solution – most commonly a set of solutions – that is actually a “best compromise” between conflicting objectives. This notion of “best compromise” rests on the preferences of the decision maker. Based on the interpretation of these preferences, it is however possible to identify a set of points in the criterion space that satisfied the definition of an optimum using Pareto optimality. Lacking a perfect knowledge of the decision maker’s utility function, Pareto optimality enables the researcher to investigate the “space of tradeoffs” between objective functions.

Definition 4.4. *Pareto Optimality*⁸⁷: A vector $x^* \in S$ is globally⁸⁸ Pareto optimal if and only if (iff) there does not exist any other vector $x' \in S$ such that $f(x') \leq f(x^*)$, and $f_i(x') < f_i(x^*)$ for at least one objective function. A vector x^* is weakly Pareto optimal iff there exists no x' such that $f(x') < f(x^*)$.

Moreover, Pareto optimal solutions can be classified as being either proper or improper (Geoffrion, 1968). Notice that in the definition given hereunder the quotient actually represents the trade-off between objective function i and objective function j .

⁸⁷ Pareto optimality has been defined by several authors, the most famous being the Karush-Kuhn-Tucker condition (Karush, 1939; Kuhn and Tucker, 1951) and the efficient point type (Koopmans).

⁸⁸ A vector can indeed be also locally optimal. Locality is traditionally defined by a circle of radius δ which centers is the vector x .

Definition 4.5. *Proper Pareto optimality:* a solution x^0 is said to be properly efficient iff it is Pareto optimal and there exists a strictly non-negative scalar M such that, for each i , we have

$$\frac{f_i(x) - f_i(x^0)}{f_j(x^0) - f_j(x)} \leq M$$

For some j such that $f_j(x) < f_j(x^0)$ whenever $x \in S$ and $f_i(x) > f_i(x^0)$

Pareto optimal solutions are thus found when no objective function can be improved without worsening at least another objective function. Weakly Pareto optimal solutions imply that there does not exist any other vector that can improve all of the objective functions simultaneously. These definitions correspond to the idea of domination relation.

Definition 4.6. *Domination Relation:* A vector $x^* \in S$ is said to dominate a vector $x' \in S$ iff (i) x^* is at least as good as x' for all objectives and (ii) x^* is strictly better than x' with respect to at least one objective.

For all intent and purposes, it can be seen that the definition of domination is identical to the definition of Pareto optimality (and by extension, to efficiency⁸⁹). In the literature however, efficiency tends to refer to a vector of decision variables in the

⁸⁹ To be more precise, Pareto optimality is a specific case of efficiency.

decision space while domination typically refers to a vector of objective function in the criterion space.

The contact theorem tells us that all Pareto optimal points for a given multiobjective programming problem lie on the boundary of the feasible objectives sub-space Z .

Theorem 4.1. *Contact Theorem:* A vector $x^* \in S$ is Pareto optimal iff

$$(C^- + x^*) \cap Z = \{x^*\}$$

where C^- is a negative cone defined in R^k such that

$$C^- = \{x^* | f(x^*) \in R^k; \text{ and } f(x^*) \leq 0\}$$

Nothing prevents the Pareto optimal set, which gathers the Pareto optimal solutions to a given problem, from being infinite. The Pareto optimal set is also geometrically known as the trade-off surface, Pareto front or Pareto frontier, an idea to which we will come back in the following sub-section. Ideally, the Pareto optimal set is a sub-set of a convex feasible region Z .

Definition 4.7. *Convexity:* A set $Z \subset R^k$ is convex iff for any $z_1, z_2 \in Z$ the points $(\lambda z_1 + (1 - \lambda)z_2) \in Z$ for all $\lambda \in [0,1]$.

4.2.3 Determining Optimal Solutions: Payoff Matrix and Pareto Front

In more than 30 years of development, various methods to solve multiobjective linear programming problems have been proposed. Colette and Siarry (2009) classified them in five categories:

- Scalar methods
- Interactive methods
- Fuzzy methods
- Metaheuristic methods
- Decision aid methods

Van Veldhuizen (1998) employs another type of categorization according to the way decision maker and analyst interact:

- *A priori* techniques: the decision maker has defined preferences even before the optimization framework is put in place. Monobjective linear programs falls in this family;
- *Progressive* techniques: the decision maker cooperates with the analyst during the optimization process to identify satisfying solutions;
- *A posteriori* techniques: the analyst provides the decision maker with a set of optimal solutions from which she will choose. For this family, the computation of the tradeoff surface is especially important.

Finding a solution to a multiobjective linear programming problem usually involves both the decision maker and the analyst. The solution process can be divided in two

parts. In a first step, the analyst tries to define the set of Pareto optimal solutions, an application of vector optimization. In a second step, the analyst will try to determine a limited number – or a unique – of optimal solutions among which the decision maker will be invited to choose. The vector satisfying the preferences of the decision maker is called the final solution.

As definitions of Pareto optimality and domination relation forcefully illustrated, there exist trade-offs between any two criteria in MOLP. Trade-offs are simply measures of how much of one objective should be sacrificed to gain an improvement in another objective, a concept that echoes the economic idea of opportunity cost. Multiobjective optimization can thus be solved by identifying the exhaustive set of trade-offs for given problem, which graphically take the form of a trade-off surface (or Pareto front). The Pareto front can more precisely be defined as the set of solutions of rank 1 determined through the definition of a domination relation and the resulting sorting process. It is noteworthy that the shapes of the Pareto fronts are not arbitrary for problems having a convex solution set (we will come back to this idea hereunder). They depend on the formulation of the MOLP and the type of optimization which is individually asked of each objective function (e.g. if $k = 2$, min-min, min-max, max-min, max-max are the four possible combinations). A good representation of a trade-off surface is given by an algorithm that provides solutions located at a regular interval on the front, in order to avoid missing potential concavities.

An important tool to assess the nature of trade-offs between criteria is the payoff matrix. The cell elements of this square matrix – whose dimensions equal the number of objective functions – are the value taken by objective functions when they are optimized individually, i.e. without taking into account the existence of the other objectives. The payoff matrix can also serve as a starting point for compromise programming algorithm, a technique we detail hereunder. Indeed, the elements in the diagonal of the matrix can be considered to form the coordinates of an ideal vector which optimizes simultaneously all the objectives⁹⁰, notwithstanding the trade-offs that must be realized between the various criteria. By the same token, the lowest value taken by the objective function in each column is the “Nadir” point (or “anti-ideal” point), a useful reference to restrict the search space.

4.3 Application Using a Small Algebraic Model

4.3.1. Introduction

The preceding sections and chapters established the context and necessary concepts necessary to the practical purpose of this dissertation. For the moment however, we have yet to combine the two instruments we presented into a coherent framework for the optimization of policy designs when policy makers are concerned by more than a single objective. It is the purpose of the rest of this chapter and of the next one.

⁹⁰ The ideal point thus does not belong to the set of feasible solution Z .

A social accounting matrix multiobjective linear programming model has, up to the extent of our knowledge, never been proposed in the literature. We thus feel that before jumping into a full-fledged model for concrete policy evaluation, it may be beneficial to elaborate and solve analytically a smaller model, which, for all intents and purposes, will have the same properties. The goal of the exercise remains the same: identifying a set of Pareto optimal solutions from which the decision maker will select a final solution she deemed reflective of her preferences.

The policy design problem is articulated around a set of variables that are introduced over the next few pages. Central among these variables are the policy criteria the decision-maker is trying to optimize. In the macro SAM framework, they will be captured by some macroeconomic aggregates⁹¹. So as to steer these indicators toward desired levels, the decision maker will mobilize a body of policy instruments, for which only plausible variations must be admitted.

For illustrative purposes, the SAM-multiobjective linear program is presented under the form a bi-criteria problem, so that we can illustrate some of our findings graphically.

⁹¹ Notice here that SAM cannot be used to evaluate any policy. For instance, because prices are exogenous, it is impossible to consider minimizing inflation as a policy objective.

4.3.2. The Model

CRITERIA AND POLICY INSTRUMENTS

Even in the case of the implementation of a generalized model, the policy design process should be started by defining both policy objectives, represented by objective functions, and policy levers, captured by the decision variables. The policy criteria and their associated objective functions are measured through macroeconomic variables.

Concerned with the depressive impact of stagnating wages on consumption and economic growth, the government's first policy objective in our model is to boost the revenues of all households as measured by the growth in real gross labor income. For simplicity purposes, it will be assumed that labor income is a positive linear function of total of value-added payments to households W , the sum of row elements for the aggregated household sector (Miller and Blair, 2009):

$$W = F + T + S + O$$

where F refers to the final consumption of goods and services by households, T to the direct taxed paid to the government, S the allocation of a certain proportion of revenues to savings and O to overseas transfers of income.

The second objective for the government is to maximize the revenues of low-income households in particular to improve equity in the society. This objective is also measured through total of value-added payments to households, but this time the SAM

matrix is sufficiently disaggregated to incorporate a row dedicated to low-income households specifically.

In other words, we thus have:

Z_1 = maximizing the revenues of all households

Z_2 = maximizing the revenues of low-income households

For convenience purposes, revenues of all households will be denoted W_{all} while revenues of low-income households will be denoted W_{low} . Notice that according to the definitions of Pareto optimality and domination relations we gave earlier, a policy $X^0 \in Z^{92}$ with feasible space coordinates $(Z_1^{X^0}, Z_2^{X^0})$ can be said to be Pareto efficient iff there is no other policy $X' \in Z$ with coordinates $(Z_1^{X'}, Z_2^{X'})$ such that $Z_1^{X'} \geq Z_1^{X^0}$ and $Z_2^{X'} > Z_2^{X^0}$ or $Z_1^{X'} > Z_1^{X^0}$ and $Z_2^{X'} \geq Z_2^{X^0}$ in the case where the two objective functions must be maximized.

Initially, we will assume that the policy maker's preferences are perfectly represented by the following utility function:

$$U(Z_1, Z_2) = Z_1 + \alpha Z_2$$

where α is a parameter.

⁹² The greek letter khi.

It can be easily seen from the equation that α acts as a weight measuring the relative importance of Z_2 compared to Z_1 . When α is set to equal 1, the policy maker is indifferent between the two objectives. When $\alpha=0$, the decision maker has no interest in maximizing the revenues perceived by low-income households. We will come back to this feature later on when solving the linear programming implementation of the problem.

A GENERAL EQUILIBRIUM MODEL OF THE ECONOMY

Let us now turn our attention to the hypothetical economy. It is assumed to be represented by the following Leontief inverse matrix:

$$[I - A]^{-1} = L = \begin{bmatrix} L_{11} & L_{12} & L_{13} & L_{14} \\ L_{21} & L_{22} & L_{23} & L_{24} \\ L_{31} & L_{32} & L_{33} & L_{34} \\ L_{41} & L_{42} & L_{43} & L_{44} \end{bmatrix} = [L_{ij}]$$

where value-added components and final demands (including of course the government) have been rendered exogenous. In this matrix, sectors 1 and 2 represent two industries while sectors 3 and 4 represent aggregated households and low-income households respectively. The presentation of the multipliers, low-income households being a sub-component of aggregated households, is unorthodox but of no consequence to the SAM-MOLP framework we will establish later by virtue of linear algebra. This reflects our use of the social accounting matrix as a database for estimating the parameters for the multiobjective linear program. The results from the

computations will not be affected by the presentation of the SAM as long as we do not take interest in an aggregate measure, for instance GDP.

To fulfill its objectives, it is assumed that the government has at its disposal a budget of size B that has been earmarked for industrial development. The government, a single and coherent agent, is the decision-maker. It decides the volume of public spending and the sectors that will be the recipient of the expenditures. Because the funds available have been earmarked for an industrial policy, the government can inject the money either in sector 1 or in sector 2, or in both. It is however impossible to channel funds directly to households (sectors 3 and 4).

It is useful here to re-write the entire model so as to get a sense of the way it will be optimized and solved. Moreover, it provides the opportunity to address a notation issue that could lead to certain confusion. In linear programming, it is traditional to denote the decision variables by x_i , whereas the exogenous shock in SAM models is denoted by f . The variable x on the other hand represents the level of output. This constitutes a problem, insofar as the column vector f actually constitutes the policy instruments – and thus the decision variables – in our model. Except for the following section, it will be understood that x_i , the vector decision variables in the multiobjective linear program, will be equal to the vector of change in final demand

Δf . The vector of output⁹³ will be denoted X . Having been clarified notations, let us jump to the model:

$$[I - A]^{-1}x = X$$

$$\begin{bmatrix} L_{11} & L_{12} & L_{13} & L_{14} \\ L_{21} & L_{22} & L_{23} & L_{24} \\ L_{31} & L_{32} & L_{33} & L_{34} \\ L_{41} & L_{42} & L_{43} & L_{44} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}$$

where we have established that x_3 and x_4 must equal zero. Generalizing, we find that:

$$[L_{ij}][x_i] = [X_i]$$

We will henceforth assume that

$$\begin{aligned} L_{ik} &= L_{31} \\ L_{ik'} &= L_{32} \\ L_{i'k} &= L_{42} \\ L_{i'k'} &= L_{42} \end{aligned}$$

THE SAM MODEL: IMPACT FORM OR PLANNING FORM?

As established in the methodological part of this chapter, the economic impact of the government's budget choices is estimated through a social accounting matrix. In order to do so, we may choose to implement the model either in its impact analysis form or in its planning form. The impact form, as its name indicates, is used to analyze the response of industry outputs and factors associated with inter-industry activities to a

⁹³ In linear algebra, it is traditional to reserve capital letters to matrices. This will be an exception.

particular final demand schedule presented to the economy. The planning form on the other hand is advantageous when seeking to optimize an objective – or a set of objectives – other than the objective implicit in traditional input-output modeling (Thoss, 1976; Blair, 1979). Indeed, the basic Leontief takes the following form, which is nothing but a special case of linear programming:

$$\begin{aligned} & Ax + f \geq x \\ \text{or} \quad & (I - A)x \geq f \end{aligned}$$

In a two sector economy, a solution to this problem can be represented graphically. The feasible region would represent every possible combination of x_i that satisfies final demand. The two binding technological constraints forming the production possibilities of this economy intersect at the input-output solution, i.e. the vector of output satisfying a given schedule of final demand. More precisely, the intersection is the point where the values taken by x_i minimize total value-added while still satisfying final demand. If q denotes total value added, then we can re-write the original two-sector Leontief model under its linear programming form:

$$\begin{aligned} \text{Minimize} \quad & q = [1 - (a_{11} + a_{21})]x_1 + [1 - (a_{12} + a_{22})]x_2 \\ \text{subject to} \quad & (1 - a_{11})x_1 - a_{12}x_2 \geq f_1 \\ \text{and} \quad & -a_{21}x_1 + (1 - a_{22})x_2 \geq f_2 \end{aligned}$$

From there, it becomes possible to formulate a generalized input-output model under its impact analysis form:

$$\begin{aligned} & \bar{x} = Hf \\ \text{where} \quad & H = \begin{bmatrix} D^* \\ L \end{bmatrix} \quad \text{and } D^* = DL \quad \text{and } \bar{x} = \begin{bmatrix} x^* \\ x \end{bmatrix} \end{aligned}$$

Note that D^* is a matrix of direct impact coefficient (dedicated to relate factors of interest such as employment, energy use or pollution to industry output) and L is the Leontief inverse matrix. H , which is created by concatenating D^* and L is a matrix of total-impact coefficients. x^* is a vector representing the levels of total impacts of the factors of interest while x is the traditional vector of output in the Leontief model. The trained eye will immediately remark that this impact form is nothing but an expansion of the classical input-output model developed by Leontief, the difference between the two consisting in the addition of two vectors of total impact to investigate other issues than the level of output (D^* and x^*).

The planning form of the generalized input-output model offers a different perspective. This form is indeed articulated around a matrix G , which is an expanded direct-impact coefficients matrix.

$$G = \begin{bmatrix} D \\ (I - A) \end{bmatrix}$$

The planning approach is generalized as follow:

$$\tilde{x} = Gx$$

where

$$\tilde{x} = \begin{bmatrix} x^* \\ f \end{bmatrix}$$

The corresponding linear programming problem has the following form:

$$\begin{array}{ll} \text{Minimize} & q = v'x \\ \text{subject to} & Gx \geq \tilde{x} \end{array}$$

This form is particularly interesting because we have provided the original Leontief model with additional constraints reflecting the existence of factors the policy-maker deems of interest (see the right-hand side of the constraint). It implies however that the new input-output model can be over-constrained, in which case the set of feasible solutions is actually empty. The linear programming is initialized by computing the values of the right-hand side constraints from the impact analysis form. These values are then modified to simulate economic growth (increase in the vector f) or the targets of some policy (change in the vector x^*). The limit of the planning form is precisely that it is extremely difficult to operate a change in the right-hand side of the constraint equation that does not eliminate altogether the feasible region. It is therefore necessary to obtain an exhaustive knowledge of the feasible set of solutions prior to changing the constraints of the linear program. If it is feasible for small problems, identifying the feasible region quickly becomes intractable as the number of policy objectives increases beyond three.

Despite its usefulness and appeal for optimization, we will employ a generalized social accounting matrix under its impact analysis form in the rest of the chapter and the following one.

NECESSARY CONDITION FOR NON-TRIVIAL MULTIOBJECTIVE OPTIMIZATION

In this chapter, we already emphasized that a necessary condition for a non-trivial use of multiobjective linear programming is the existence of a conflict between at least two objective functions. Therefore, we must have that:

$$\begin{array}{ll} L_{ik} > L_{ik'} & \text{or} \\ L_{i'k} < L_{i'k'} & \end{array} \quad \begin{array}{l} L_{ik} < L_{ik'} \\ L_{i'k} > L_{i'k'} \end{array}$$

Indeed, if $L_{ik} > L_{ik'}$ and $L_{i'k} > L_{i'k'}$ holds simultaneously, then injecting all the funds in sector k would result in optimizing both Z_1 and Z_2 . Consequently, the problem would be of a trivial nature. An interesting feature of social accounting matrix is that thanks to its convenient presentation in matrix form, it is easy to extract the set of linear equations summarizing the impact of the exogenous shock(s) on the economy. Therefore, conflicts between objective functions can be revealed straightforwardly.

The relations between the Leontief coefficients in the same column are left undefined because inter-households equity is not a policy objective of the decision maker here. To reduce inequalities in society, the policy maker might actually been interested in injecting money where $L_{i'j} > L_{ij}$ for $j = k, k'$. This would imply that the income earned by low-income households would actually catch up with the income earned by all households. One can argue that this measure is even more interesting than the one we selected because equity issues are comparative in nature, rather than absolute. Our model can indeed reach an optimal solution resulting in the best absolute improvement for labor income of both types of households, but in a rise in inequalities since aggregate households' income may be progressing at a faster rate than the revenues of

low-income households. For simplicity purposes however, we will keep our original policy design.

NON-NEGATIVITY AND STRICT POSITIVITY OF PARAMETERS

Another interesting feature of SAM should also be noted. Each of the terms A used in the series approximation $[I - A]^{-1}$ contains only non-negative elements. Indeed, the Hawkins-Simon conditions (Hawkins and Simon, 1949) stipulate that as long as $[I - A] > 0$, then all elements in the Leontief inverse matrix will be non-negative⁹⁴. Because $L_{ij} \geq 0 \forall i, j$ objectives will be strictly increasing in x as long as the vector of final demands shock $x_i > 0$ for at least one x_i ($i = 1, \dots, n$). We can bypass the need to investigate the principal minors of the Leontief matrix using the condition developed by Dietzenbacher (2005): if the original data are $Z^0 > 0$ and $x^0 \geq 0$ (with at least one $x_i^0 > 0$), then $L^0 = [I - A^0]^{-1} > 0$ and $X^1 = L^0 x^1 \geq 0$ for any $x^1 \geq 0$. Requirements for Z^0 and x^0 are easily checked in a social accounting matrix. In our example, we will assume that $Z^0 > 0$ and we know from the policy design problem under scrutiny that at least one x_i^0 will be strictly positive, i.e. that the government must spend its earmarked budget B .

⁹⁴ The proof can be found in Hawkins and Simon (1949). The intuition is that as $[I - A]^{-1} = \begin{bmatrix} \frac{(1-a_{22})}{|I-A|} & \frac{a_{12}}{|I-A|} \\ \frac{a_{21}}{|I-A|} & \frac{(1-a_{11})}{|I-A|} \end{bmatrix}$ and knowing from basic input-output that $a_{ij} \geq 0$ and $a_{ij} < 1$, $|I - A|$ is non-negative. Hereby, $[I - A]^{-1}$ has non-negative elements (Miller and Blair, 2009).

It is also important to note that as it has been demonstrated that $L_{ij} \geq 0$, every additional dollar injected in any sector of the economy will result in the improvement (except when $L_{ij} = 0$) of the utility function $U(Z_1, Z_2) = Z_1 + \alpha Z_2$.

4.3.3. Implementation of the Model

PRELIMINARIES

The multiobjective linear programming implementation of the problem is as follow:

Objective functions:

$$\text{Max } Z_1 = L_{ik}x_k + L_{ik'}x_{k'}$$

$$\text{Max } Z_2 = L_{i'k}x_k + L_{i'k'}x_{k'}$$

Constraints:

$$\begin{aligned} \text{subject to } \quad & x_k + x_{k'} \leq B \\ & x_i = 0 \quad \forall i \neq k, k' \\ & x_i \geq 0 \quad \forall i \end{aligned}$$

The constraints are such that it is actually possible for the government to inject the integrality of its budget in a single sector. This could be changed by transforming the third constraints to a strictly positive condition for the column vectors k and k' .

Inasmuch as we determined a utility function mapping the preferences of the decision maker, we can re-write the objective function under a familiar form, that of a single objective linear program.

Objective function:

$$\text{Max } U(Z_1, Z_2) = Z_1 + \alpha Z_2$$

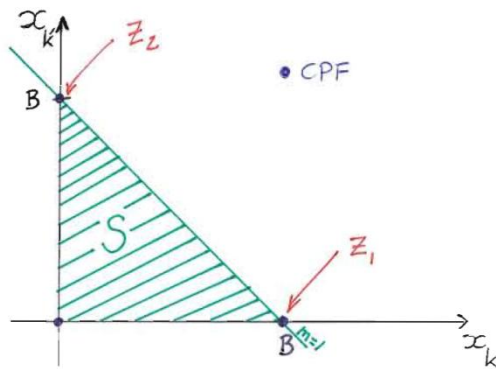
or when developed

$$\text{Max } U(Z_1, Z_2) = (L_{ik}x_k + L_{ik'}x_{k'}) + \alpha(L_{i'k}x_k + L_{i'k'}x_{k'})$$

THE PROBLEM IN DECISION AND CRITERION SPACES

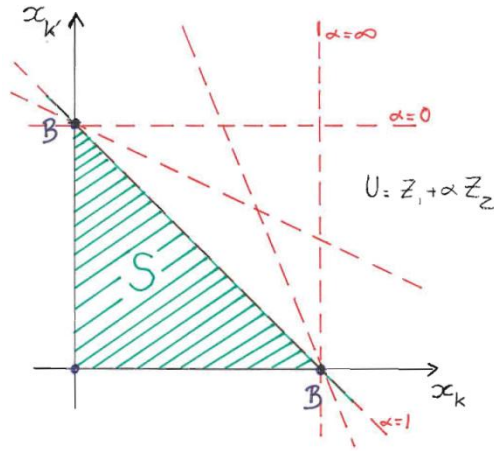
Having only two decision variables, x_k and $x_{k'}$, it is possible to solve the linear programming problem graphically. Representing the problem in the decision space, we note that there exist three corner point feasible (CPF) solutions, two of which can be considered optimal depending on the objective function to maximize.

Figure 4.2. Solutions in the decision space



Our knowledge of the policy maker's utility function offers a simple way to solve the problem by mapping said function in the two-dimensional Euclidean decision variables space.

Figure 4.3. Solving with the decision maker's utility function



Only two optimal solutions emerge from the decision maker's preferences, as captured by $U(Z_1, Z_2) = Z_1 + \alpha Z_2$, except when α is set to equal one. In this case, an infinite number of optimal solutions exist. The utility function indeed corresponds to the binding constraint $x_k + x_{k'} \leq B$. α measuring the relative importance of the two objectives, setting $\alpha = 1$ means that the policy maker is indifferent between maximizing the income of all households and that of low-income households. Ergo, any amount of fund can be channeled in either of the two sectors without violating the stated preferences of the decision maker. On the contrary, if $\alpha = 0$, then the policy maker does not care about the labor-income perceived by low-income households in which case the original multiobjective framework is transformed into a monobjective one, where Z_I is the only measure of performance under consideration. When $1 < \alpha < \infty$, the decision maker displays her preference for low-income households' revenues over the revenues earned by all households. Accordingly, when $0 \leq \alpha < 1$, the decision maker favors all households.

Despite its simplicity, this problem illustrates a central feature of multiobjective linear programming: the importance of the decision maker in the establishment of an optimal solution. Perhaps more importantly, this example enables us to introduce graphically the concept of feasible region in the criterion space. Consider the original MOLP where the feasible region in decision space we just illustrated is denoted S , whereas Z will denote the feasible region in criterion space. In set theoretic notation,

$$Z = \{z \in R^k | z = Cx, x \in S\}$$

which means that Z is the set of images of all points included in S . A point worth mentioning is that Z is not necessarily confined to the nonnegative orthant of R^k , even if S is.

With respect to the original MOLP, it is possible to transfer the linear problem's graphical representation from the decision space to the criterion space by identifying the set of criterion vectors associated with the corner point feasible solutions of S . They are as follow:

$$\begin{aligned} A = (0, B) & \rightarrow A' = (L_{ik'}x_{k'}, L_{i'k'}x_{k'}) \\ B = (0, 0) & \rightarrow B' = (0, 0) \quad \text{Nadir point} \\ C = (B, 0) & \rightarrow C' = (L_{ik}x_k, L_{i'k}x_k) \end{aligned}$$

Defintion 4.8. *Nadir point*: its coordinates correspond to the worst values obtained on each objective function while restricting the solutions set to the trade-off surface. The Nadir point is used to restrict the search space and ameliorate the computing time of the algorithm.

⁹⁵ Also called “Utopia point”.

A point $z^{**} \in Z^k$ is an ideal point iff for each $i = 1, 2, \dots, k$, $z_i^{**} = \min_{x \in S} \{z_i(x)\}$

IDENTIFYING THE PARETO FRONT

Up until now, only a graphical representation of the MOLP has been offered. In order to solve the problem, domination relation among the solutions must be established. Similarly to single objective linear programming, we are interested in optimal solutions to the Pareto, a small subset of the feasible criterion space Z . In particular, it is crucial to identify the set of nondominated criterion vector.

Definition 4.10. *Nondominated vector:* Let $\bar{z} \in Z$. Then \bar{z} is a nondominated criterion vector if and only if there is no other vector $z \in Z$ such that $z \geq \bar{z}$ and $z \neq \bar{z}$. If this is the case, \bar{z} is a dominated criterion vector. The inverse image of \bar{z} in S , called \bar{x} is by definition efficient (or Pareto optimal)⁹⁶.

To compare various solutions, we must first recall that the policy maker wishes to see Z_1 and Z_2 maximized. Therefore, a point P in the criterion space dominates a point Q in the same space considering objective Z_1 if $Z_1(P)$ has a larger value than $Z_1(Q)$; a point P is better than a point Q with respect to objective Z_2 if $Z_2(P)$ has a larger value than $Z_2(Q)$. It is then possible to classify the set of solutions to the problem in the following way:

⁹⁶ It is said that efficient points are *contenders for optimality*.

Table 4.2. The Payoff Matrix: a table of the values of the criteria for a selection of feasible points

Point	Objective Z_1	Objective Z_2
A'	$L_{ik'}x_{k'}$	$L_{i'k'}x_{k'}$
B'	0	0
C'	$L_{ik}x_k$	$L_{i'k}x_k$
D'	$L_{ik}\varphi x_k + L_{ik'}(1 - \varphi)x_{k'}$	$L_{i'k}\varphi x_k + L_{i'k'}(1 - \varphi)x_{k'}$

where $0 < \varphi < 1$

D' is an intermediate point on the Pareto tradeoff surface (see preceding graph)

Table 4.3. Corresponding classification of solutions

	A'	B'	C'	D'
A'		(+, +)	(-, +)	(-, +)
B'	(-, -)		(-, -)	(-, -)
C'	(+, -)	(+, +)		(+, -)
D'	(+, -)	(+, +)	(-, +)	

- Graphically, it can be seen that A' is worse than C' considering objective Z_1 . Therefore, the first element in the cell $[A', C']$ is a minus. Reciprocally, the second element in the cell $[C', A']$ is a minus as well.
- Similarly, we observe that A' is better than C' with respect to objective Z_2 . Consequently, the second element in the cell $[A', C']$ is a plus.
- B' being worse than the other points selected with respect to both objectives, it is attributed a double minus for its row.

Then, it is possible to say that point B' , the Nadir point, will not belong to the set of nondominated solutions of rank 1 because it is possible to find at least one point (A' , C' or D') which is better than B' on all objective functions. As for A' , C' and D' , they all belong to the set of nondominated points N according to the following theorem:

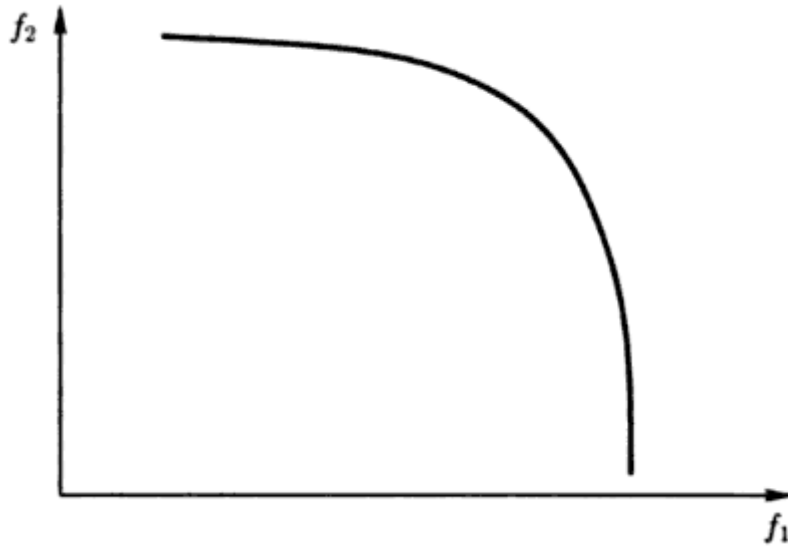
Theorem 4.2.

Let $U: R^k \rightarrow R$ be a coordinatewise increasing utility function. Then, if $z \in Z$, is optimal, z is nondominated.

Proof. (Steuer, 1985:148) Suppose z is dominated. Then, there exists a $\bar{z} \in Z$ such that $\bar{z} \geq z$, $\bar{z} \neq z$. Since U is coordinatewise increasing, this means $U(\bar{z}) > U(z)$, which contradicts the optimality of z . Thus, z is nondominated. ■

Thanks to the classification of solution, we have already established that A' , C' and D' do not dominate themselves, so that they can be called Pareto optimal solutions of rank 1. This sorting rule, based upon the concept of domination relation, creates the tradeoff surface or Pareto front, which gathers the set N of Pareto optimal solutions of rank 1. The tradeoff surface we represented in our solution graph is consistent with the shape of a max-max problem (maximizing both objective functions) with a convex solution set.

Figure 4.5. Theoretical shape of a tradeoff surface for a max-max problem with a convex solution set.



4.3.4. Algorithm and Solution

INTRODUCING COMPROMISE PROGRAMMING

To solve our program we will use a type of compromise solution, a technique that yields a single optimal solution⁹⁷. The key point of compromise solutions, also known as “distance-to-a-reference-objective method”, is to minimize the topological distance between the vector under consideration, member of the set of nondominated solutions N , and the ideal vector z^{**} (Yu, 1973; Zeleny, 1973). The Pareto optimal solution which is the closest to the ideal vector is the compromise solution. Of course, the meaning of close is dependent on the metric selected. In this case, the absolute Euclidean distance $N(x)$ is the measure of choice, as the two objective functions are expressed in the same unit (US dollars):

$$N(x) = |z(x) - z^{**}| = \left\{ \sum_1^k |z_i(x) - z_i^{**}|^r \right\}^{1/r}$$

With $1 \leq r \leq \infty$

Keeping this in mind, we may now propose a specific method to solve the MOLP. The augmented weighted Tchebycheff (also written Chebyshev by certain authors) procedure, a type of weighting vector space reduction method, has been selected (Steuer and Choo, 1983). Using this procedure has several advantages, including the fact that the objective vectors z_i need not be linear, nor the set of feasible solution in

⁹⁷ The approach is thus very close to single objective LP. Once the model has been run, a unique solution is proposed for the decision maker's approval.

the decision space S need be convex. Moreover, the algorithm can converge to non-extreme solutions and can compute unsupported and improperly nondominated criterion vectors. To obtain a final solution, the algorithm follows a progressively more concentrated sampling strategy respecting the preferences of the decision maker. It is therefore classified as an interactive technique, where the analyst requires the input of the decision maker to enable the model to converge to a satisfying conclusion. The algorithm operates in a pre-determined number of iterations and computes a fixed number of solutions per iteration.

The general formulation for the weighted Tchebycheff method is as follow:

$$U = \max_i \{\lambda_i [z_i(x) - z_i^{**}]\}$$

where U is called an achievement function, λ is a vector of weights set by the decision maker such that $\sum_{i=1}^k \lambda_i = 1$ and $\lambda > 0$. The weighted Tchebycheff procedure is the limit⁹⁸ of equation $N(x)$ as $r \rightarrow \infty$.

$$\lambda \in \Lambda = \left\{ \lambda \in R^k \left| \lambda_i > 0, \sum_{i=1}^k \lambda_i = 1 \right. \right\}$$

Steuer and Choo (1983) however recommend to use another set of weighting vectors $\lambda \in \bar{\Lambda}$, where $\bar{\Lambda}$ is the set of all nonnegative weighting vectors, to give birth to the augmented weighted Tchebycheff method:

⁹⁸ Setting $r \rightarrow \infty$ allows a complete identification of the Pareto optimal set (Messac et al, 2000).

$$\bar{\Lambda} = \left\{ \lambda \in R^k \left| \lambda_i \geq 0, \sum_{i=1}^k \lambda_i = 1 \right. \right\}$$

This set is used to define different weighted Tchebycheff metrics in such a way that the probability of obtaining a weakly Pareto optimal solution – a risk of the classical weighted Tchebycheff procedure – is reduced to zero (Miettinen, 1999). The weighted Tchebycheff metric will be the yardstick used to measure the distance between a Pareto optimal vector $z \in R^k$ and the ideal point z^{**} :

$$\|z^{**} - z\|_{\infty}^{\lambda} = \max_{i=1, \dots, k} \{\lambda_i |z_i^{**} - z_i|\}$$

Let us define

$$|||z^{**} - z|||_{\infty}^{\lambda} = \|z^{**} - z\|_{\infty}^{\lambda} + \rho \sum_{i=1}^k |z_i^{**} - z_i|$$

as a member of the family of augmented weighted Tchebycheff metrics. We have families of $\|z^{**} - z\|_{\infty}^{\lambda}$ and $|||z^{**} - z|||_{\infty}^{\lambda}$ metrics because $\lambda \in \bar{\Lambda}$. We use the word augmented with reference to the $|||z^{**} - z|||_{\infty}^{\lambda}$ metric because of the $\rho \sum_{i=1}^k |z_i^{**} - z_i|$ term, in which ρ is a sufficiently small positive number. We can write the general formulation for the augmented weighted Tchebycheff method as follow:

$$U = |||z^{**} - z|||_{\infty}^{\lambda} = \max_{i=1, \dots, k} \left\{ \lambda_i [z_i^{**} - z_i] + \rho \sum_{i=1}^k |z_i^{**} - z_i| \right\}$$

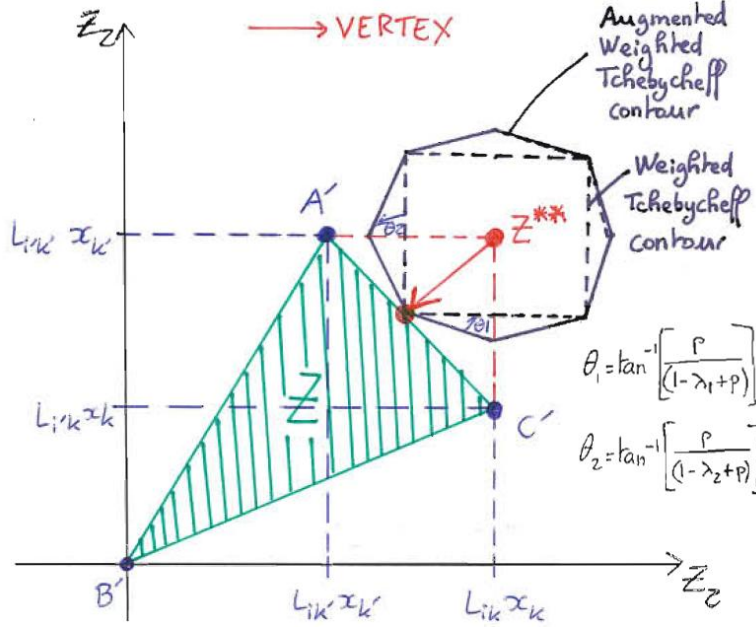
The method is appealing for polyhedral problems⁹⁹, such as the one we are facing, since optimizing the achievement function will necessarily result in Pareto optimality as long as the scalar ρ is not too large (Steuer, 1986). One can immediately remark that if $\rho = 0$, then the metric for the augmented weighted Tchebycheff and the weighted Tchebycheff will be identical.

This lengthy mathematical presentation of the augmented Tchebycheff method can be summarized in the following graph. It can be seen that the purpose of the procedure is to establish two contours centered on the ideal criterion vector and tangentially scanning the set of nondominated solutions (the tradeoff surface). The contours consist of the loci¹⁰⁰ of points equidistant from z^{**} according to their respective metrics, i.e. either the weighted Tchebycheff or the augmented weighted Tchebycheff. The contour for the weighted Tchebycheff metric has a rectangular shape, whereas the contour for the augmented weighted Tchebycheff metric is an octagon.

⁹⁹ Polyhedral problems are a class of problem with only linear constraints.

¹⁰⁰ A loci is a set of all points satisfying a given set of conditions.

Figure 4.6. Contours of the $\|z^{**} - z\|_\infty^\lambda$ and $\|z^{**} - z\|_\infty^\lambda$ metrics and optimal solution for the MOLP



In this case, \bar{z} is at the same time the definition point and the vertex of each of the contours. The line segment connecting z^{**} with \bar{z} is the diagonal of the contours, and the arrow linking the two points specifies the diagonal direction of each contour. Notice here that we make reference to *the* diagonal direction of the contours because we solve the problem in a two-dimensional Euclidean space. If k , the number of objective functions, was superior to two, then the direction specified by $(\bar{z} - z^{**})$ would be *a* diagonal direction of the contours.

Definition 4.11. *Definition point:* Let $\bar{z} \leq z^{**}$ and $\lambda \in \bar{\Lambda}$. Then \bar{z} is a definition point of the $|||z^{**} - z|||_{\infty}^{\lambda}$ contour if and only if

$$\lambda_i = \begin{cases} \frac{1}{z_i^{**} - \bar{z}_i} \left[\sum_{i=1}^k \frac{1}{z_i^{**} - \bar{z}_i} \right]^{-1} & \text{if } \bar{z}_i \neq z_i^{**} \ \forall i \\ 1 & \text{if } \bar{z}_i = z_i^{**} \\ 0 & \text{if } \bar{z}_i \neq z_i^{**} \text{ but } \exists j \ni \bar{z}_j = z_j^{**} \end{cases}$$

In our model, it is possible to graphically observed that \bar{z}_i , defined as all the points on the segment $[A', C']$, is different from z_i^{**} for all i 's. Consequently, the first condition applies.

Definition 4.12. *Vertex:* Let $\bar{z} < z^{**}$. Then \bar{z} is a vertex of a given $|||z^{**} - z|||_{\infty}^{\lambda}$ contour if and only if \bar{z} is an extreme point of the closed convex set in R^k whose boundary is the contour.

From definition 4.12, we conclude that if D' is a vertex of the augmented weighted Tchebycheff contour presented in the previous graph, this is not the case for A' and C' , because $A', C' \nless z^{**}$.

THE AUGMENTED WEIGHTED TCHEBYCHEFF ALGORITHM

Suppose that in figure 4.6. we wish to determine the point $\bar{z} \in Z$ that is the closest to the z^{**} ideal criterion vector according to the augmented weighted Tchebycheff metric. What we need is a program to discover $\bar{z} \in Z$, much like the Simplex method

is used to solve monobjective linear programming problems. The augmented weighted Tchebycheff program is:

$$\begin{aligned}
 \text{Min} \quad & \left\{ \alpha + \rho \sum_{i=1}^k |z_i^{**} - z_i| \right\} \\
 \text{subject to} \quad & \alpha \geq \lambda_i [z_i^{**} - z_i] \quad 1 \leq i \leq k \\
 & Z_i(x) = z_i \quad 1 \leq i \leq k \\
 & x \in S
 \end{aligned}$$

where α is a minimax variable since its purpose is to minimize the maximum weighted z_i deviation from z_i^{**} . The original multiobjective linear programming has been transformed into a single objective linear programming problem.

The solution to this program will take the form of a vector $(\bar{x}, \bar{z}, \alpha) \in R^{n+k+1}$ where \bar{z} is the closest criterion vector to the ideal criterion vector and \bar{x} is its inverse image in the decision space. Of course, running the algorithm is not possible for an algebraic model, and thus a specific solution cannot be pinpointed without the recourse to graphs.

The way the algorithm is implemented is relatively straightforward: it samples a shrinking proportion of the Pareto front with each iteration. The procedure is initialized after an ideal point has been identified. The first iteration starts by creating a dispersed group of λ -weighting vectors. As we have demonstrated previously, this group of weighting vectors will create various augmented weighted Tchebycheff metrics. The vertices of these contours span the integrality of the Pareto front and offer

the decision maker with a sample of the set of nondominated solutions to her problem. The size of this sample set is pre-determined and fixed across iterations. Among this sample, the decision maker is asked to select a solution she deems tailored to her preferences.

The second iteration is a repetition of the first step, but with another group of λ -weighting vectors which vertices span this time a more concentrated sub-space around the first vector solution identified by the decision maker. A new set of nondominated solutions emerge, and the decision maker selects her preferred one. The process repeats itself up until the decision maker finds a solution she is satisfied with.

Calibration of the augmented weighted Tchebycheff algorithm thus requires a certain number of information from the analyst (Steuer, 1986):

- An ideal point z^{**} to initialize the procedure;
- A specification of the sample size P , with $P \geq k$;
- A pre-determined number of iterations t , with $t = k$;
- A $\bar{\Lambda}$ -reduction factor r (which rules the changes brought by each iteration to

the λ -weighting vectors), with $\sqrt[k]{\frac{1}{P}} \leq r \leq {}^{t-1}\sqrt{w}$.

The bounds around the solution i selected by the policy maker at iteration h are denoted $[\vartheta_i^h, \mu_i^h]$, and w is the interval width for the final iteration (Steuer and Wood, 1986):

$$\frac{1}{2k} \leq r \leq \frac{3}{2k}$$

AN ANALYTIC SOLUTION TO THE MODEL

The fact that we cannot run the algorithm with an algebraic problem offers us two solutions through which to close this chapter. Returning to the graph presented in figure 2.2. (section 4.3.3.), in which case we will immediately see that an infinity of solutions may be drawn from the inverse image of Pareto front in the decision space. Each of this point, unsurprisingly, represents a different allocation of the budget mix where both sectors x_k and $x_{k'}$ received some funding. The allocation is entirely specified by the preferences of the decision maker. The nature of the model, small and linear, does not actually require using an algorithm to be solved.

However, it is possible to ascertain the existence of a set of analytical solutions regulated by the vertex of the augmented weighted Tchebycheff contour. In our model, we can graphically determined that $\bar{z}_i^{**} \neq z_i^{**} \forall i$, which implies that:

$$\lambda_i = \frac{1}{z_i^{**} - \bar{z}_i} \left[\sum_{i=1}^k \frac{1}{z_i^{**} - \bar{z}_i} \right]^{-1} \quad (4.1)$$

Yet, we know that:

$$z_i^{**} - \bar{z}_i^{**} = \begin{bmatrix} L_{ik}B \\ L_{i'k}B \end{bmatrix} - \begin{bmatrix} L_{ik}\varphi B + L_{ik'}(1-\varphi)B \\ L_{i'k}\varphi B + L_{i'k'}(1-\varphi)B \end{bmatrix}$$

where $0 < \varphi < 1$

Thus, we obtain:

$$[z_i^{**} - \bar{z}_i^{**}] = \begin{bmatrix} L_{ik}B - L_{ik}\varphi B - L_{ik'}(1 - \varphi)B \\ L_{i'k'}B - L_{i'k}\varphi B - L_{i'k'}(1 - \varphi)B \end{bmatrix}$$

We must now reorganize this cumbersome expression into a more elegant factorized form:

$$[z_i^{**} - \bar{z}_i^{**}] = \begin{bmatrix} (B - \varphi B)(L_{ik} - L_{ik'}) \\ \varphi B(L_{i'k'} - L_{i'k}) \end{bmatrix}$$

Notice that because $L_{ik} > L_{ik'}$, $L_{i'k'} > L_{i'k}$ and $0 < \varphi < 1$, we have demonstrated without the help of the graph that $\bar{z}_i^{**} \neq z_i^{**} \forall i$. The topographical distance between the two vectors is indeed strictly positive vis-à-vis both criteria. Moreover, it appears clearly that the vector \bar{z}_i^{**} is dominated by z_i^{**} .

Let us now introduce the following notations:

$$(L_{ik} - L_{ik'}) = \psi$$

$$(L_{i'k'} - L_{i'k}) = \Omega$$

$$\varphi B = \kappa$$

Reintroducing part the λ_i -weighting vector from equation (4.1), we see that¹⁰¹:

¹⁰¹ Let us not forget that this expression represents the sum of the topological distance between z_i^{**} and \bar{z}_i^{**} relative to Z_1 and the topological distance between z_i^{**} and \bar{z}_i^{**} relative to Z_2 . These distances are the elements of the matrix $[z_i^{**} - \bar{z}_i^{**}]$ we already computed.

$$\left[\sum_{i=1}^2 \frac{1}{z_i^{**} - \bar{z}_i} \right]^{-1} = \left[\frac{1}{(B - \kappa)\psi} + \frac{1}{\kappa\Omega} \right]^{-1} = \left[\frac{\kappa\Omega + (B - \kappa)\psi}{\kappa\Omega[(B - \kappa)\psi]} \right]^{-1}$$

which is a scalar. Therefore, the inverse of this matrix is simply the reciprocal of its value, or:

$$\left[\frac{\kappa\Omega + (B - \kappa)\psi}{\kappa\Omega[(B - \kappa)\psi]} \right]^{-1} = \left[\frac{\kappa\Omega[(B - \kappa)\psi]}{\kappa\Omega + (B - \kappa)\psi} \right]$$

Thus, re-writing equation (1) this time in its integrality:

$$\lambda_1 = \left[\frac{1}{(B - \kappa)\psi} \right] \left[\frac{\kappa\Omega[(B - \kappa)\psi]}{\kappa\Omega + (B - \kappa)\psi} \right] = \left[\frac{\kappa\Omega}{\kappa\Omega + (B - \kappa)\psi} \right]$$

$$\lambda_2 = \left[\frac{1}{\kappa\Omega} \right] \left[\frac{\kappa\Omega[(B - \kappa)\psi]}{\kappa\Omega + (B - \kappa)\psi} \right] = \left[\frac{(B - \kappa)\psi}{\kappa\Omega + (B - \kappa)\psi} \right]$$

The graph presented in figure 4.6. portrays the generalized

$\lambda = \left[\frac{\kappa\Omega}{\kappa\Omega + (B - \kappa)\psi}, \frac{[(B - \kappa)\psi]}{\kappa\Omega + (B - \kappa)\psi} \right]$ contour that has \bar{z} as its vertex and

definition point. Computing the diagonal direction of the contour, we have¹⁰²:

$$-\left(\frac{1}{\lambda_1}, \frac{1}{\lambda_2} \right) = -\left(\frac{\kappa\Omega + (B - \kappa)\psi}{\kappa\Omega}, \frac{\kappa\Omega + (B - \kappa)\psi}{(B - \kappa)\psi} \right)$$

¹⁰² Notice the negative sign preceding the vector, typical for a max-max optimization problem.

CONCLUSION

The diagonal direction of the contour presented in the last equation is the same for the augmented weighted Tchebycheff contour $\|z^{**} - z\|_{\infty}^{\lambda}$ and the weighted Tchebycheff contour $\|z^{**} - z\|_{\infty}^{\lambda}$. Because the Lp-metric, set to infinity, does not change, the variation in the contour can only come from two elements:

- The definition of the ideal point z^{**} , that we know fixed in our case¹⁰³;
- The λ -weighting vector.

From our computations, it is clear that the only variable in the diagonal direction of the contour is $\kappa = \varphi B$, or the share of the budget attributed to x_k and x_k' . Other elements are all derived from parameters extracted from the social accounting matrix (ψ and Ω) or exogenously determined (B , the size of the budget).

This may seem as if we have been turning in circles for most of the chapter. The analytical solution we deliver indeed reveals the overarching importance of κ on the outcome of the algorithm. Once again, the preferences of the decision maker come to haunt us. Then, what has changed?

It must actually be understood that the usefulness of our framework directly derived from the fact that the augmented weighted Tchebycheff contours are computed through an algorithm. This is a major difference with trying to solve the problem in the decision space, as we did earlier in the chapter. In the decision space, we get

¹⁰³ That is, we have no reason of proposing another ideal vector given the knowledge of the feasible region we possess.

rapidly stuck if we do not obtain a mathematical expression – a utility function for instance – from the policy maker. The main problematic faced by the analyst is then less to propose an alternative set of solutions to the decision maker than to desperately attempt at formulating the preferences of the decision maker. By using multiobjective optimization, we steer away from this difficulty: the algorithm, through numerous iterations, provides Pareto optimal solutions for different budget mixes. The analyst (and even the decision maker) is agnostic vis-à-vis preferences¹⁰⁴. Through the model, they gain a better understanding of the trade-offs at stake, and progress toward the definition of preferences that will be embodied in the final solution.

As the model grows more complex, incorporates more decision variables and objective functions, and as the ability to graph solutions vanishes, this feature proves especially attractive. One however should not expect too much from multiobjective optimization. Contrarily to its close cousin, traditional linear programming, MOO does not offer a unique solution. Additionally, the technique requires in general more computational effort than monobjective programming (Marler and Arora, 2004). This is especially true for methods – such as the one proposed here – that use an a posteriori articulation of preferences¹⁰⁵. Despite these downsides, we believe that multiobjective linear programming can be fruitfully used for policy analysis in correlation with social accounting matrices, as we hope to have demonstrated in this chapter.

¹⁰⁴ This is not entirely true inasmuch as the analyst determines the ideal point as well as the calibration of the model, influencing the results derived from the implementation of the algorithm.

¹⁰⁵ Computational time can be drastically reduced by using genetic algorithms.

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Chapter V

PARETO OPTIMAL POLICIES IN A SOCIAL ACCOUNTING MATRIX: A MULTIOBJECTIVE APPROACH TO FISCAL RETRENCHMENT IN NEW YORK STATE EMPLOYING A GENETIC ALGORITHM AND CONSTRAINT PROGRAMMING

5.1 Preliminaries

The purpose of this thesis up to this chapter has been to provide public decision makers with a new theoretical framework capable of combining macroeconomic impact analysis – under the form of a Walrasian equilibrium model – and a tool to optimize policies with respect to given objectives. Chapter IV introduced such a model based on a social accounting matrix and a multi-objective linear program (MOLP). We demonstrated, at least mathematically, how the model would work and how it could result in the selection of the best set of alternatives available to policy-makers through the identification of a Pareto front. The perspective adopted has been that of a unitary

decision maker evolving in an environment without uncertainties¹⁰⁶. It will remain so in the following paragraphs.

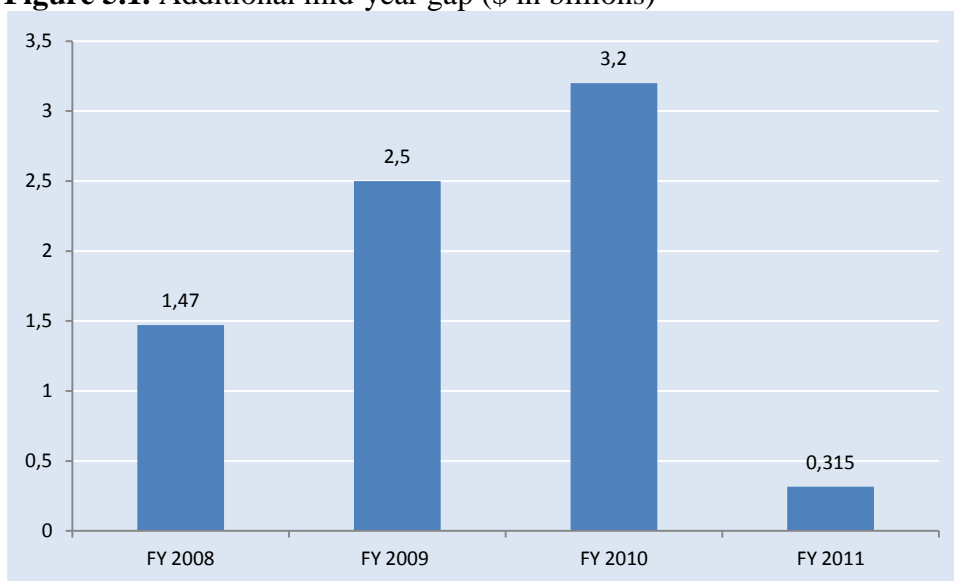
In this chapter we present an application of this model to an area where policy making is particularly intricate, and where the effects of tradeoffs on the economy are all the more complex to assess that they span categories that are by no mean fungible: public finance, and in particular the management of fiscal deficits during or following a recession. The interest of this chapter is twofold. Firstly, to identify a set of fiscal policies such that there is, *in equilibrium*, no possibility to make an improvement in one attribute without accepting a sacrifice in another. Secondly, and perhaps more importantly, to reveal the existence or inexistence of inefficiencies in the policy adopted by the State of New York with respect to pre-defined objectives.

We have illustrated in chapter III how New York State's public finances have been hard hit by the financial crisis, and that both Governor Paterson and Cuomo emphasized the importance of budget cuts to ensure the sustainability of the state's finances. Under such trying circumstances, policy makers in Albany are typically under the pressure of accomplishing several competing objectives simultaneously through the budget. Prominent among these objectives are employment, balancing the budget, ensuring a sustainable level of equity in society and limiting the contraction in local private capital expenditures. It is therefore clear, as we established in the introductory chapter, that budgetary decisions can be interpreted as multi-faceted

¹⁰⁶ Multi-objective linear programming can be adapted to fit collective decision making. For instance, see Kilgour, Chen and Hipel (2010).

problems where a wide range of policy instruments can be mobilized to achieve specific outcomes. The problematic of competing policy objectives is especially acute for mid-year budget cuts. Contrarily to tax increases, their impact on the economy tend to be immediate (Benson and Johnson, 1986), and their formulation must strike a delicate balance between the necessary act of reducing the deficit and the negative consequences this might have on aggregate consumption – and thus growth, employment and human capital.

Figure 5.1. Additional mid-year gap (\$ in billions)



Source: New York State Division of Budget

Closing multi-billion dollars mid-year budget gaps in an efficient fashion is critical from an economic standpoint, but it is also vital from a purely political perspective. A tough budget decision is easier to pass if it does not entail a lower well-being than it strictly has to.

In our case, we argue for a fiscal policy design articulated around economic objectives only. This is of course simplistic, and it is worth noting that the social accounting matrix framework can be customized to incorporate other concerns of the policy maker. For instance, the Governor might very well wish to evaluate the potential ecological impact of cutting the budget of the Department of Environmental Conservation or lengthening the lifespan of coal-fired power plants. Environmental input-output analysis can be helpful in this context.

In section 2, we present the policy that will be scrutinized through the lens of the social accounting matrix multiobjective linear programming model. Section 3 introduces the architecture of the model and its main components, while the mathematical formulation of the problem at hand is reviewed in section 4.

5.2 The Policy Under Consideration: Governor Paterson's Deficit Reduction Plan

The focus of this thesis has been on fiscal policy and more precisely how state governments ought to manage the mid-year budget cuts that can arise in situations of increased fiscal stress. In this model, the policy instrument is thus conceived as the amount of budget that should be retrenched from each spending program in order to satisfy the state's balanced budget requirements in the most efficient fashion (see section 5.4.1 hereunder). By extension, the model provides useful guidance to policy-makers insofar as it becomes possible to compare on a unified scale the respective

performances of a “benchmark” distribution of the budget cuts as defined by the model and the policy alternatives defined by the state administration.

It was illustrated in chapter IV that the methodology proposed relied heavily on the multiobjective linear programming part of the model. Indeed, if the use of a social accounting matrix represents a choice in the theoretical framework which undergirds the economic impact analysis, the policy part of the model is essentially derived from the formulation of a linear program. Once the social accounting matrix has been selected, substantial improvement can still be made so that it fits more precisely the conditions prevalent to the region of interest. Nonetheless, much of the flexibility in the methodology we propose comes from the linear programming part, as it is possible to manipulate simultaneously several aspects of the overall policy design: policy instruments, policy objectives, constraint and even uncertainty in the variables. This is why so much attention will be devoted to the MOLP.

The first step in creating the linear programming model is to establish an overall target level for budget cuts. In other words, by how much should the state of New York reduce its expenditures to achieve fiscal sustainability? Even though theoretical works on fiscal sustainability exist (see for instance Greiner and Fincke, 2009), it is clear that the desirable size of the budget gap is primarily a political matter. This is the case in New York State because if the executive budget submitted by the governor for every fiscal year must be, by constitutional provision, balanced¹⁰⁷, no such obligation applies

¹⁰⁷ 43 other states have the same provision.

to the state legislature¹⁰⁸ (NASBO, 2008). Moreover, the state is authorized to carry over the deficit¹⁰⁹ to the next fiscal year. This prompted the U.S. Advisory Commission on Intergovernmental Relations to rank New York as one of the four states with the least stringent balanced budget requirements¹¹⁰ in the country, along with Massachusetts, Vermont and New Hampshire¹¹¹ (Advisory Commission on Intergovernmental Relations, 1987).

When it comes to mid-year budget gaps the governor has the initiative and concentrates most of the decision-making power. This is of special interest to us because spending cuts are the principal – when not the only – tool pushed by governors to close gaps between revenues and expenditures emerging during the fiscal year. We will thus devote our attention to the management of mid-year budget gaps, and use the FY 2010 gap of \$3.2 billion to run the model.

In order to eliminate the entire FY2009-10 current-year budget gap, Governor Cuomo proposed on October 15, 2009 a Deficit Reduction Plan totaling approximately \$3.16 billion. The plan called for a set of actions that can be implemented administratively by the Executive branch and requiring for other actions the approval of the Legislature or other parties. They are summarized in the following table.

¹⁰⁸ New York shares this characteristic with 9 other states: Hawaii, Indiana, Missouri, New Hampshire, Pennsylvania, Vermont, Virginia, Washington and Wisconsin.

¹⁰⁹ 12 other states can legally carry over their deficit: Arizona, Connecticut, Illinois, Maryland, Massachusetts, Michigan, New Jersey, Pennsylvania, Texas, Vermont, West Virginia and Wisconsin.

¹¹⁰ The constitutional and statutory citations for the balanced budget requirements can be found in the Article 7, §2 of the New York State Constitution and in the Legislative Law, §54.

¹¹¹ California and New Jersey were classified in the “most stringent” category.

Table 5.1. Deficit Reduction Plan for 2009-2010 (in million dollars)

Administrative Actions	833
State Operations Across-the-Board Reductions	484
Medicaid Fraud Targets	150
Debt Management	100
18-A Utility Assessments ¹¹²	45
Workers' Compensations Surplus Recapture	49
Dormant Funds	5
Actions Requiring Legislative/Other Approval	2,326
Local Assistance Across-the-Board Reductions	1,300
School Aid (\$686 million school year reduction)	480
Health Care (including insurance)	343
Transportation	125
All Other	352
Battery Park City Resource (Need NYC Approval)	300
Statewide Audit/Recovery Targets/Amnesty (Tax)	250
VLT Franchise Payment (Assumes Current Year Settlement)	200
Regional Greenhouse Gas Initiative Fund/EPF Fund Sweep	100
DASNY Fund Sweep	26
Other Actions	150
Total Deficit Reduction Plan Actions	3,159

Source: New York State Division of Budget

http://www.budget.ny.gov/pubs/archive/fy0910archive/enacted0910/midYear_update/0910midyear_DRP.html

Among these, only a handful can be strictly considered budget cuts:

- **State operations across-the-board reductions** (\$484 million): an 11% reduction to agency operating budgets
- **Local assistance across-the-board reductions** (\$1.3 billion): a 10% reduction to all remaining, undisbursed local assistance spending in FY 2010.
 - School aid: \$480.3 million
 - Health care (including insurance): \$343 million

¹¹² Refers to the public utility companies, corporations and persons subject to the public service commission's regulation (Article 1 §18-A of the Public Service Consolidated Laws of New York).

- Transportation: \$125.4 million
 - All other¹¹³: \$352 million
- **Other actions** (\$150 million): potential actions that could be implemented to realize additional savings. It includes the in-sourcing of IT activities pursuant to legislation to modernize civil service rules, further controls on specific agency activities, the use of funds currently earmarked for debt management purposes, and other initiatives. The nature of these actions is ill-defined, and we will allocate 70% of them to local assistance reductions and the remaining to state operations reductions.

We will eliminate from the model actions pertaining to Medicaid fraud. Even if we could divide the \$150 million recovered by New York State between provider fraud, waste and abuse and recipient fraud, the language of the plan is not sufficiently clear to provide a solid foundation for modeling. Moreover, Medicaid fraud is not systematically measured and as part of the non-observed economy is absent from our data set. We discard additional revenues from tax audit for similar reasons.

We deem ‘Debt management’¹¹⁴, ‘18-A utility assessment’¹¹⁵, ‘Workers’ compensation surplus recapture’¹¹⁶ and ‘Aqueduct VLT franchise payment’¹¹⁷ to

¹¹³ All other expenditures in states includes the Children’s Health Insurance Program (CHIP), institutional and community care for the mentally ill and developmentally disabled, public health programs, employer contributions to pensions and health benefits (only partially taken into account in the case of New York State), economic development, environmental projects, state police, parks and recreation, housing, and general aid to local governments

¹¹⁴ Realization of savings compared to debt service estimates from refunding, the use of Build America Bonds and relatively low interest rates on variable rate bonds.

constitute revenue measures rather than budget cuts. They may thus be safely ignored in our model. As for ‘Dormant funds’¹¹⁸, ‘Battery Park city resource’¹¹⁹, ‘Regional greenhouse gas initiative’¹²⁰ and ‘DASNY fund sweep’¹²¹, they are not included because they represent accounting transfers.

The Deficit Reduction Plan is an interesting illustration of the principle that the size of the state’s deficit is managed politically rather than being the pure product of economic management. Indeed, we observed that a substantial proportion of the initiatives taken to close the budget gap may not materialize. Because the topic of interest in this dissertation is fiscal retrenchment, it is possible to go even further: the final amount of budget cuts deemed appropriate by the Governor’s office is of a purely political nature (e.g. it is conceivable that the Executive can adopt a fiscal policy relying solely on budget cuts, or inversely on revenue measures).

This statement has important practical implications for our methodology: it cannot formulate recommendations about a potential efficient policy mix of budget cuts and revenue measures, just an arbitrage among several categories of budget cuts. In other words, the overall target level for fiscal retrenchment in this model is a *parameter*. It has to be defined exogenously by the decision maker. In order to provide the decision

¹¹⁵ Re-estimation of the amount of revenue generated from an increased assessment on utilities enacted in 2009-2010.

¹¹⁶ Certain insurers indicated their intention to remit excess funds.

¹¹⁷ Assume that the winning Aqueduct VLT bidder will make a franchise payment.

¹¹⁸ Part of the money held in dormant accounts will be made available to the General Fund.

¹¹⁹ State would receive excess revenues from the Authority.

¹²⁰ Transfer of RGGI proceeds and EPF funds to the General Fund.

¹²¹ Receive funds from the Dormitory Authority of the State of New York (DASNY).

maker with an analysis of budget cuts *versus* revenue increases in terms of efficiency a computable general equilibrium model would be better suited than a social accounting matrix. The latter is indeed poorly adapted to model accurately revenue measures, and in particular changes in tax policy¹²². The former, in which prices are endogenously determined, appears as a pertinent alternative to tackle such an issue.

It is therefore logical to take the Deficit Reduction Plan as a basis to define the overall target level for budget cuts, ignoring the fact that the resulting policy mix might itself not be efficient in the Pareto sense. This is as a source of theoretical discomfort from the perspective of economics. Indeed, nothing guarantees that the optimal distribution of budget cuts yielded by our SAM-MOLP model would correspond to a Pareto efficient outcome in the case of a policy mobilizing both spending and revenue tools. Under a particular fiscal policy, the results from the model can actually lead to a sub-efficient allocation of resources. Two sets of restrictive assumptions can assist in overcoming this difficulty:

- (i) To consider that the mid-year budget gaps are overwhelmingly closed through fiscal retrenchments, and that revenue policies do not affect significantly the economic system. The empirical work of Romer and Romer (2007) suggests that there is a strong negative correlation between tax increases and output growth, but that this relation is weaker when the legislated tax change aims at reducing a budget deficit;

¹²² Evaluation of tax policy is a core application of CGE modeling. Because prices are absent from the social accounting matrix, it is unable to capture effectively changes in tax policy.

- (ii) To establish hypotheses about the nature of budget cuts and revenue measures in the SAM-MOLP framework. Indeed, it can be seen easily from the short model we developed in chapter IV that if both policies are perfectly fungible, if each policy's impact is modeled in a consistent manner (e.g. a negative shock on final demand) and if the sectors affected are the same, then the SAM multipliers guarantee that in equilibrium optimizing one of the two aspects of fiscal policy will yield a Pareto optimal result.

Using set notation, this hypothesis translates as:

$$S_c = \{\{x_c | c \text{ a sector affected by budget cuts}\}\}$$

$$S_r = \{\{x_r | r \text{ a sector affected by revenue measures}\}\}$$

Then, $S_r \subseteq S_c$.

Having established this relationship, it is possible to relax slightly the hypothesis. In order to do so, we must first take a little detour by the nuts and bolts of the SAM-MOLP model. Because the goal of the multiobjective linear program the SAM-MOLP model is to determine which negative shocks on final demand will have the smallest impact on a collection of policy objectives, its drivers will be (i) the multipliers of the matrices used to evaluate these objectives (e.g. if the criteria of interest is employment, then the coefficients of the employment row vector) and

(ii) the amounts of the cut / revenue measures. To see this more clearly, we can use generalized input-output analysis, which tells us that it is possible to concatenate several direct-impact coefficient matrices into a single matrix. This leads to formulate the input-output problem in a manner that is particularly well suited to our purpose. In chapter IV, we demonstrated how the planning form of the generalized input-output model could be derived, and we established that:

$$\begin{bmatrix} x^* \\ f \end{bmatrix} = \begin{bmatrix} D \\ (I - A) \end{bmatrix} [x]$$

Which is the same as

$$Gx = \tilde{x}$$

The G matrix corresponds to the multipliers we referred to earlier, i.e. parameters of the model, while the x matrix represents policy alternatives under the form of an exogenous shock. Individual elements in the G matrix are denoted $[G_{ij}]$. Note that theoretically the G matrix concatenated all the factors associated with interindustry activities that we deem relevant to our policy analysis. It may be employment, or pollution, or even energy intensity. It does not matter as long as they vary linearly with output. The performance of the policy alternatives with regard to objectives are captured in the \tilde{x} column vector. The MOLP algorithm we will use to solve the model will look at the set of policies that yield the most efficient results in terms of \tilde{x} .

With respect to the original question of relaxing the assumption, this circumlocution tells us that S_r need not be a subset of S_c ($S_r \not\subset S_c$) for the optimization process to yield a *globally* Pareto efficient set of solutions. Assuming the notation used previously and that $S_r \setminus S_c \neq \emptyset$, optimizing the budget cuts will result in a globally Pareto efficient fiscal policy mix if and only if it can be proven that the smallest¹²³ $G_{ij}x_c$ is larger than the largest of $G_{ij}x_c$, as long as budget cuts and revenue measures are allowed to vary freely on the interval $[0; BG]$ where BG is the mid-year budget gap. Notice that because we used the concatenated matrix G , this holds true for any \mathbb{R}^k .

Recalling the graph used in chapter IV to present a geometrical solution *in the criteria space* to a SAM-MOLP model, the condition just expressed implies that:

$\nexists G_{ij}x_r \rightarrow Z$ which contributes to form a vector of non-dominated solutions in \mathbb{R}^k .

Consequently, vectors created from $G_{ij}x_r$ simply belong to the set of feasible solutions, but not to the Pareto front.

One additional assumption must be made for the hypothesis to hold: each dollar saved or obtained by the state through its fiscal policy is affected to the deficit, which consists in debt detained by non-resident bondholders.

¹²³ The expression is somewhat counter-intuitive because in the case of a negative shock on final demand we are interested in the behavior of the objective functions in the third quadrant. As $-1,000 < -500$, the larger the impact the better for the economy.

Indeed, if it were not the case and say some of the additional receipts (in the form of increased revenues or new resources freed by budget cuts) were re-injected under one form or another in the regional economy, then optimizing the SAM-MOLP model would not necessarily yield a set of optimal alternatives. The framework would indeed fail to take into account the effects of this indirect shock.

From the perspective of political science however, the absence of revenue measures from our model is somewhat less distressing. As empirical evidences suggest a weak negative electoral effect of taxation for governors¹²⁴ (Kone and Winters, 1993), state and local governments appear to clearly favor spending cuts over revenue measures during episodes of recession, as detailed in chapter II. As long as this preference endures, a model focusing on fiscal retrenchments seems politically appealing.

For all these reasons, we thus opted for a “one stage” optimization rather than for a more cumbersome “two stages” optimization in which we would first offer an arbitrage between budget cuts and revenue measures and then detail which cuts / revenues should be targeted for improvement. As such, the Deficit Reduction Plan proposed by Governor Cuomo provides a good starting point for the model. Furthermore, it has the advantage of already reflecting some of the arbitrages that overshadowed the budget negotiations. This is a crucial point, inasmuch as in the context of this dissertation, optimization is useful only when it is politically feasible.

¹²⁴ Interestingly enough, there does not seem to be a statistically significant correlation between electoral support and a decrease in taxation.

5.3 A Social Accounting Matrix Multiobjective Linear Programming Model for Fiscal Retrenchment Policies in New York State

5.3.1 A General Equilibrium Model of New York State

The core of the model presented in this chapter is a social accounting matrix (SAM) with trade flows estimated through econometric relative power contribution (RPC) for New York State in 2006. The data set used to create the SAM was provided by the Minnesota IMPLAN Group (MIG). This social accounting matrix enabled us to observe and describe the prevailing characteristics and the structure of the state's economy in chapter III. It may now be introduced to trace the equilibrium impacts of a selection of fiscal retrenchment policies on macroeconomic variables, thus fulfilling its role as a type of Walrasian general equilibrium model. The equilibrium state of the economy is given by a vector of activity level, i.e. output, for all endogenous sectors satisfying the condition that total outlays equal total output in all markets.

Given that the last dataset available for the economy of New York State was 2006, we make the key assumption that the matrices derived from IMPLAN fully capture the structural and behavioral characteristics of the state's economy in 2009-10. Moreover, it is assumed that some features of the model remain fixed. As we have seen previously, this is the case of the technological coefficients of the Leontief inverse matrix. But this is also the case of inter-institutional transfers, of the ownership of factors and of the saving and consumption patterns of households. This last category

implies that the income elasticities of demand, albeit different for each of the nine household types, is constant.

As we briefly mentioned in the introduction to this dissertation, using the social accounting matrices provided by MIG comes at a price: the inability to conform the design of the underlying data system to the specific needs of the study. For instance, as will appear clearly in the following pages, the level of disaggregation of the sub-national public sector – combining state and local governments – is somewhat unfit to our purpose. Indeed, the sector is divided between a ‘State and Local Governments Education’ (sector 503 in IMPLAN) and a ‘State and Local Governments Non-education’ (sector 504 in IMPLAN) account, hardly disaggregated enough for a methodical analysis of fiscal retrenchment policies at the state level. A positive point is that the structure of public spending is appropriately detailed, as current and capital expenditures are separated into two different accounts (capital expenditures are captured in the ‘State and Local Governments Investment’ account).

Furthermore, a social accounting matrix offers a good basis toward more complex models, such as computable general equilibrium, and can even be transformed into a dynamic model (see for instance Alarcón et al., 2011). This chapter will be confined to the social accounting matrix as a fixed-price multiplier model and will provide a comprehensive picture of the circular flow of all payments in the regional economy of New York State at a given point in time. Contrarily to the framework developed by Alarcón et al., this chapter sticks to a conventional static model and thus ignores the

adjustment process underwent by each endogenous variable before reaching a state of equilibrium.

By selecting a social accounting matrix over alternative models such as financial social accounting matrices (Emini and Fofack, 2004) or financial computable general equilibriums (F-CGE) the focus of the study is brought over the real side of the economy. The absence of a clear snapshot of the financial markets and of the transactions of assets and liabilities between agents, lumped into a single highly aggregated ‘capital account’, is a second area of theoretical discomfort after the one detailed in section 5.2. Closing mid-year budget gaps can be considered an exercise in fiscal sustainability, a policy objective that is impossible to incorporate using a real social accounting matrix. That is, the SAM-MOLP model is agnostic when it comes to the management of the public debt. For instance, our algorithm could point out that transportation should be specifically targeted for budget cuts because its current contribution as specified in the Deficit Reduction Plan results in a sub-optimal policy mix. The increased pressure on transportation could however lead to a report and a raise in the cost of necessary public works, a distinct breach of fiscal sustainability. This explains partly why fiscal sustainability has been eliminated from the model as a policy objective. On the other hand, the limited size of mid-year budget gaps compared to overall deficits, the narrow scope to make the decisions that will close these gaps and the speed at which arbitrages must be rendered means that long term fiscal sustainability may not be of the utmost importance for policy-makers. This issue

is indeed better addressed during the elaboration of the budget for the entire fiscal year.

Consequently, it would be advantageous to sift the Pareto optimal alternatives yielded by the SAM-MOLP model through frameworks commonly used in the literature to assess the impact of particular policies on fiscal sustainability. These are endogenous growth models (Moraga and Vidal, 2004; Annicchiarico and Giammarioli, 2004) and dynamic stochastic general equilibrium models (Leeper, Plante and Traum, 2010; Sakuragawa and Hosono, 2010).

5.3.2 The State and Local Governments Sector in New York State

As detailed in chapter III, data from IMPLAN clearly illustrates the importance of the state and local governments in the economy of New York. Education, the single largest area of expenditures for Albany, is by far the largest employer in the state, although it lags behind other sectors in terms of income per worker and output. We also find in the ranking other sectors that are closely linked to state government expenditures, including “state and local non-education”, “hospitals”, “social assistance” and “nursing and residential care facilities”.

Table 5.2. New York State’s largest sectors in 2006

Sector	Employment	Labor Income	Output	Output/Worker	Income/Worker
State & Local Education	701,767	\$37,042,630,000	\$40,393,820,000	\$57,560	\$52,785
State & Local Non-Education	547,540	\$40,422,460,000	\$44,079,430,000	\$80,504	\$73,826
Food services and	502,347	\$10,806,920,000	\$29,199,580,000	\$58,126	\$21,513

drinking places					
Real estate	387,230	\$15,633,890,000	\$93,288,550,000	\$240,913	\$40,374
Wholesale trade	385,720	\$30,064,140,000	\$79,386,980,000	\$205,815	\$77,943
Hospitals	329,971	\$20,342,400,000	\$40,082,260,000	\$121,472	\$61,649
Social assistance- except child day care services	320,514	\$7,689,525,000	\$12,251,390,000	\$38,224	\$23,991
Securities- commodity contracts- investments	315,348	\$83,208,420,000	\$98,256,970,000	\$311,583	\$263,862
Offices of physicians- dentists	280,396	\$20,148,930,000	\$33,110,190,000	\$118,084	\$71,859
Nursing and residential care facilities	229,396	\$8,645,075,000	\$13,101,430,000	\$57,113	\$37,686

Source: IMPLAN

A complete image of the activities of the state and local governments is provided in the following table:

Table 5.3. A snapshot of the State and Local Governments sector

Sector	Employment	Output	Value Added	Intermediate Expenditures
State & Local Education	701,767	\$40,393,820,000	\$40,393,820,000	(\$3,906)
State & Local Non-Education	547,540	\$44,079,430,000	\$44,079,430,000	(\$7,813)
State & Local Passenger transit	2,190	\$130,348,600	\$45,207,030	\$85,141,540
State & Local Electric Utilities	657	\$204,566,800	\$97,784,760	\$106,782,000
Other State & Local government enterprises	55,176	\$14,133,820,000	\$6,373,547,000	\$7,760,273,000

Source: IMPLAN

Figures from the New York State Department of Labor (Gardner and Paterson, 2010), although somewhat different from those provided by IMPLAN, confirm the prominent place of education in the state's economy. The education sector concentrated 867,900 jobs in September 2009, a 3.7% growth over 2006, while the total number of jobs in the economy receded by 0.6%. The average weekly wage in the sector was \$930 however, one of the lowest in New York.

Table 5.4. Comparison of significant industries in New York State

Sector	Job Count		Change	Projected Change (2006-2016)	Average Weekly Wage
	2006	2009			
All Industries	8,368,500	8,315,600	-0.6%	6.2%	\$1,080
Hospitals	411,900	429,800	4.3%	1.6%	\$1,110
Nursing...	263,900	272,900	3.4%	20.7%	\$600
Ambulatory...	357,900	393,400	9.9%	25.8%	\$900
Construction	84,000	82,800	-1.3%	22.9%	\$1,060
Securities...	196,700	187,800	-4.6%	24%	\$5,590
Education...	836,700	867,900	3.7%	8.3%	\$930

Source: NYS Department of Labor

5.3.3 Detailing the Social Accounting Matrix

The SAM-MOLP model used in this dissertation is calibrated from the 2006 New York State SAM published by MIG, which counts a total of 509 sectors broken down as follow:

- **The inter-industry transaction matrix**, gathering 483 industries along the lines defined by the U.S. Census Bureau in its 2002 North American Industry Classification System (NAICS);
- **Value-added**, divided into 4 accounts: employee compensation (labor), proprietary income and other property income (capital) and indirect business tax;
- **The institutions**: 9 household groups categorized according to their annual income, the federal government, state and local governments and enterprises (corporations);
- **Investment and savings** (capital)
- **Adjustments** (inventory additions and deletions)

- **Foreign and domestic trade:** the organization of this account is specific to regional SAMs. Trade flows are indeed divided into domestic trade, i.e. trade activities taking place between New York State and the rest of the U.S., and foreign trade, which accounts for exchange realized with partners beyond the national borders.

Given modern computers' computational power, the 526×526 could be kept entirely disaggregated for the purpose of this study. To investigate the results would however be tremendously complicated. It appears therefore preferable to use a modified aggregated SAM to reduce the matrix to more tractable dimensions. In order to do so, we chose to select the NAICS-2 aggregation scheme available directly from IMPLAN built-in library of aggregation. However, we customized it to our needs, conserving the original level of disaggregation for certain institutional accounts and certain industries.

The proposed model is a 49×49 SAM. In this new SAM, a distinction must be brought between endogenous and exogenous accounts if we want to carry out controlled experiments of the impact of given fiscal policy on a pre-determined¹²⁵ set of endogenous variables. The nature of our study is such that the origin of the exogenous shocks modifying the equilibrium of New York's socio-economic system has been determined to be the budget retrenchment policy that the state government must

¹²⁵ The relevant endogenous variables depend on the policy objectives identified by the decision maker.

implement in order to close mid-year budget gaps. Therefore, the following accounts shall be considered exogenous (all definitions are from Olson, 2011):

- State/Local Governments Education: “the operational spending pattern of all levels of public education, from pre-K to higher education”;
- State/Local Government Non-education: “the operational spending pattern of all other divisions of administrative state and local governments including legislature, police, fire, hospitals, prisons, etc. but excluding market driven (enterprise) activities such as sewer, water, power and public transportation”;
- State/Local Government Investment: “the new construction and capital goods expenditures by all levels of state and local governments”.

Only part of the state and local governments sector is actually made exogenous, since as an institution it also has attached “holding” sectors to account for its payroll and employment. These two holding sectors (one for non-education, the other for education) will remain endogenous, and will form elements in the final policy instrument vector.

It is also common to render exogenous other accounts that are not endogenously determined in a regional economy. Ergo, the ‘domestic and foreign trade’, ‘capital’, ‘federal government’, ‘inventory’ and ‘rest of the world’ accounts shall all be treated as exogenous variables.

To better understand the flow of funds from and to the two most important governmental accounts identified previously, it is interesting to take a closer look at the row elements of the SAM.

‘State and Local Government Non-Education’ gather the payments made by state and local governments to five different institutions: following the organization of the SAM, these are commodities¹²⁶, households, state and local government education and foreign and domestic trade. The first category, commodities, directly relates to the payment of domestic goods and services. It essentially amounts to the non-education domestic final demand of state and local governments. Payments to households are made under the form of transfers – in particular unemployment and welfare – and more rarely interest to bondholders. The non-education accounts also transfer some funds to the education account, representing the allocation of money from the state and local administrations (non-education) to accommodate education expenditures. Finally, both state and local governments import foreign goods, a flow that is represented at the intersection of the ‘State and Local Government Non-Education’ row and the ‘Foreign Trade’ column.

‘The State and Local Government Education’ account is more succinct. As with ‘State and Local Government Non-Education’, payments are made to acquire domestic commodities, representing a form of final demand. There are however no transfers to

¹²⁶ The underlying data sets from which the IMPLAN regional social accounting matrices are built use a commodity-by-industry format.

households or to other governmental accounts, but there is a flow to foreign imported goods and services.

5.4 Implementing Multiobjective Optimization: Policy Instruments, Policy Objectives and Pareto Optimality

5.4.1 The Policy Instrument: Retrenchment across Spending Domains

The focus of this dissertation is on the optimal distribution of budget cuts across spending domains to close mid-year budget gaps. Mid-year budget cuts logically constitute the policy instrument available to the decision maker to close the state's budget gap. Budget cuts, which will be denoted x , are modeled by negative public expenditures in a number of targeted sectors. The targeted sectors, referred to by a subscript t in subsequent equations, have been presented in section 5.2 so that we have:

$$[x_t] = \begin{bmatrix} x_{SLG} \\ x_{K12} \\ x_{HE} \\ x_{PA} \\ x_{HC} \\ x_T \end{bmatrix}$$

where subscripts SLG corresponds to administrative expenditures for State and Local Governments; $K12$ to elementary and secondary education; HE to higher education; PA to public assistance; HC to health care; and finally T to transportation.

Varying the pattern of these government expenditure accounts through a multiobjective linear programming model will allow us to investigate the impact of counterfactual policy scenarios on the entire socio-economic system of New York State and more precisely on the set of policy objectives selected. Mathematically, it is simply tantamount to create alternative exogenous column-vectors $[x_t]$ and measuring their respective effects on the endogenous Z vector of objectives. The MOLP enables to systematically inspect a very large number of experiments, instead of formulating a definite number of alternatives and examine them one at a time.

Modeling the policy instruments through negative public expenditures implies that $x_t \leq 0$ for all t . This technique was first introduced by Leontief et al. (1965) in their study of the impact of a reduced defense budget in the United States. It was reproduced by Keuning and Thorbecke (1989) in a paper dealing with the impact of fiscal policy on income distribution in Indonesia. In both works the budget retrenchments are first expressed as a percentage change from before being expressed in monetary units. Because our study is based on figures in dollar, we will directly jump to expressions written in monetary units.

Interestingly enough, the use of negative injection to simulate fiscal retrenchment policies agrees well with social accounting matrices. *Ceteris paribus*, shrinking public expenditures lower the rate of utilization of productive capacities by economic agents, which satisfies the assumption that there is excess capacity in the economy. Therefore, the fact that prices are not allowed to vary in social accounting matrices should not

handicap the SAM-MOLP model. On the contrary, it might be argued that other types of Walrasian general equilibrium frameworks which allow for prices to adjust, such as CGE models, may well not be as appropriate to simulate the economic impact of budget cuts as far as this point is concerned.

Technically, the nature of mid-year budget cuts is more complex than the x_t column-vector would let appear. They are indeed deducted from the remaining funds made available to each program by the original legislated budget for the entire fiscal year, i.e. they constitute a retrenchment from a decrease (or increase) in public spending. In the case of a decrease and if we denote by Δx_{t+1} , in dollar, the legislated change in expenditures for the entire fiscal year¹²⁷, then we may express mathematically the total budgetary impact of a retrenchment policy as follow:

$$\Delta x_{t+1}^j + \alpha \Delta x_{t+1}^j = \Delta x_{t+1}^j \quad 0 \leq \alpha \leq M \quad (1)$$

where M is a large number. It seems highly unlikely that a budget cut could actually become larger than the original amount retrenched, but it is nonetheless possible. For clarity purposes, we changed all the signs to positive.

Because Δx_{t+1}^j is a part of the enacted budget, it might be tempting to discard it as an irrelevant variable from the optimization model. If reintegrated into a simple social accounting matrix, it is possible to see that the expression $\Delta x_{t+1}^j + \alpha \Delta x_{t+1}^j$ is actually

¹²⁷ For New York State, this would be the so-called “enacted budget”, which covers the fiscal year (April 1 – March 31).

a column-vector which would be pre-multiplied by the Leontief inverse matrix to obtain a final demand vector. As a consequence and in virtue of matrix algebra, both Δx_{t+1}^j and $\alpha \Delta x_{t+1}^j$ share the same multiplier L_{ij} . *Ceteris paribus*, optimizing one is therefore tantamount to optimizing the other. The *ceteris paribus* condition is of course a reference to the policy objectives and constraints that rule the optimization program. It is unclear whether or not the decision maker shares a unique set of objectives for the fiscal year budget and subsequent adjustments alike. For instance, we have seen that fiscal sustainability may not be an overarching policy objective when it comes down to closing a mounting mid-year budget gap whereas it is a central preoccupation during the crafting of the fiscal year budget. In that case, the optimization problem should be solved in the R^{k+1} criterion space instead of the R^k space. In itself, this does not constitute a violation of the idea that optimizing $\alpha \Delta x_{t+1}^j$ and optimizing Δx_{t+1}^j yield the same mathematical result. But it does if the new policy objective is independent of the criteria already existing.

The fact that mid-year budget cuts constitute a retrenchment from a legislated change in public spending has also practical implications. The cuts must indeed be implemented during the fiscal year on funds that have not been already disbursed. This means that $\alpha \Delta x_{t+1}^j$ is actually not time independent. The original expression (1) must be transformed to take into account this fact:

$$\Delta x_{t+1}^j + \alpha x_{t+\theta}^j = \Delta X_{t+1}^j \quad 0 \leq \alpha \leq M$$

where $x_{t+\theta}^j$, a stock, represent the amount of money left in the public coffers after time θ .

The expression $\alpha x_{t+\theta}^j$ is however cumbersome to carry on as such. It is more elegant to switch its implications to constraints, so that the column-vector $[x_t]$ we use in subsequent paragraphs is bounded by the amount of funds left in the coffer at time θ , the time at which the decision to cut budgets is made.

These two findings (that the SAM-MOLP model is (i) dependent on the budget voted for the entire fiscal year and (ii) dependent on how much time passed since the beginning of the fiscal year) are an important reminder that policy making is never done into a vacuum.

5.4.2 The Constraints of the Multiobjective Linear Programming Model

VARIATIONS IN THE VECTOR OF POLICY INSTRUMENT

The difficulty, then, is to develop a precise sense of what is politically feasible in terms of fiscal retrenchment. In other words, we must get a sense of the constraints that limit the amount of budget cuts that can be realized in any single program. The best way to do so is to offer a cross-sectional analysis of cutback management and identify the typical distribution of mid-year budget cuts in the United States. Ideally, this should be combined with a time series analysis focusing on New York State only.

Episodes of fiscal crises and data covering them are however scarce, and it is thus dubious that such a model could be created.

Even in the presence of strong statistical evidences favoring a particular distribution of budget cuts, it is unclear whether or not the findings should be systematically applied. Poterba (1994) found that fiscal adjustments are dependent not only on institutions but also on political factors. Governmental budgetary processes in the states characteristically rest on a divided budget authority whose actors can have incompatible interests and goals. For instance, theoretical and empirical suggest that while bureaucracies tend to aim at increasing the amount of resources they control, elected officials tend to value more a politically beneficial distribution of scarce resources and acceptable levels of deficit (Niskanen, 1971; Niskanen, 1975; Fields et al., 1997; Bealey and Coate, 2000; Alesina and Tabellini, 2004). Moreover, the unprecedented size of the mid-year budget gaps faced by the state of New York following the 2007 recession implies that history may not be a good indicator of how deficits should be handled.

That being said, the exercise of defining the constraints of our linear program is made easier by the very nature of budget cuts. They indeed are the result of intense political negotiations, bargaining and lobbying. Accordingly, enacted budget cuts tend to reflect prevailing preferences and dominating influences in the political establishment. In the case of New York State, the initiative for budget talks lies in the hands of the governor. This is all the more true when budget deficits emerge during the course of

the fiscal year since the Executive is constitutionally required to manage the finances of the state (and guarantee they remain balanced) after the annual budget has been enacted. The propositions drafted by the Governor's staff thus irrefutably constitute the starting point of budget negotiations, and the Deficit Reduction Plan under study here is no exception. It is consequently realistic to interpret the constraints on the policy instrument as potential deviations from the values proposed in the Deficit Reduction Plan. Then, the model not only determines a set of optimal distributions of budget cuts across spending domains, it also contribute to identify the areas where marginal improvements should be negotiated. Using the Deficit Reduction Plan has a basis to elaborate the constraints of the model has another advantage with respect to the fact that mid-year budget cuts are time dependent (see previous section). Because the plan is drafted for implementation, it already takes into account the possibility that some programs have already spent important amounts of the funds they were allocated at the beginning of the fiscal year.

In this light, the very nature of multiobjective linear programming becomes evident. Its calibration is the result of an intense exchange between the decision maker and the modeler. This interactive aspect of MOLP is present for both policy objectives and constraints, as we have just illustrated. Because we were unable to meet the actors of the budgetary process in New York State, we argue that the Deficit Reduction Plan offers a good proxy for interaction, as it already incorporates a range of what is realistically feasible to close the mid-year budget gap.

Quantitatively, we will assume that fiscal retrenchment policies targeting any given program cannot deviate by more than 15% from the values they takes in the Deficit Reduction plan, or

$$0.85x_t \leq x_t \leq 1.15x_t \quad \forall t$$

It is implied here that a change toward the upper bound $1.15x_t$ would not violate the time-dependency condition established in the previous section. That is:

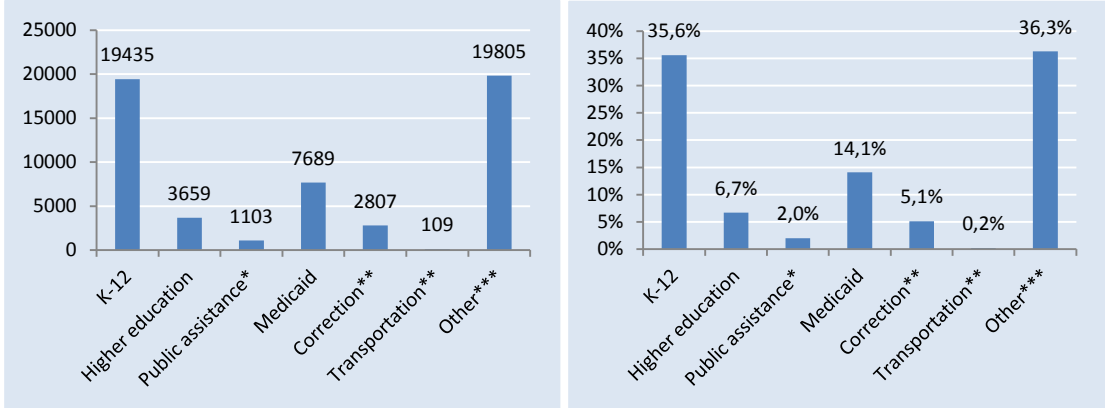
$$1.15x_t \leq \alpha x_{t+\theta}^t \quad \forall t$$

We may briefly mention a danger with this approach. The Governor's propositions could indeed target only specific programs and leave out others, in which case the formulation of our vector of policy instrument would be biased by construction. This is typically not the case with mid-year budget cuts because they practically always involve across-the-board spending reductions. Another criticism could be addressed to the model if the figures presented in the Governor's plan are demonstrated to be overly skewed to accomplish political motives. Once again, this is rarely the case with mid-year budget cuts, since there is not much leeway left after several rounds of fiscal management under severe stress¹²⁸. And the space to maneuver is all the more limited that state budgets are heavily dominated by three programs: education, Medicaid and assistance to local governments. Hence, cuts large enough to balance a budget

¹²⁸ Mid-year budget gaps appear after deficits already manifested themselves for the full fiscal year.

spiraling into deficit must be realized in a restricted number of areas, mainly education (cumulating K-12 and higher education) and Medicaid.

Figure 5.2. Structure of New York State’s general fund for FY2009



a. in million dollars (total general fund expenditures: \$54.6 billion)
 * AFDC/TANF and other cash expenditures
 ** including CAPEX
 *** State government and aid to local governments
 Source: U.S. Census Bureau

b. in percentage

RESPECTING THE “GOLDEN RULE”

Of course, close attention to the set of constraints defined up until now will reveal a major inconsistency. Given the social accounting matrix’s positive and linear multipliers, optimizing the budget cuts will simply result in the model converging toward the lower bound of our set of constraints. Logically, the lower the cuts, the lower the impact on the state’s economy. Henceforth, another constraint must be added in order for the SAM-MOLP model to yield another policy mix than zero cuts everywhere.

The primary objective of mid-year fiscal retrenchment is to eliminate the budget gap that appeared during the fiscal year. But then, shouldn’t this consideration be modeled

through an objective? This could be done, but in fact it is simpler and theoretically more correct to introduce the balanced budget as a constraint rather than as an objective¹²⁹. Therefore, we have that:

$$\sum_{t=1}^6 x_t = BG$$

where BG is the budget gap.

Incorporating the “Golden Rule” into the constraints ensures that the model *must* meet this specification, and that it is not the object of any potential tradeoff.

5.4.3 Policy Objectives

A very common type of public policy analysis is the study of the implications of new spending program on an economy, not just the traditional impact analysis concerned with aggregate output level. It is a more comprehensive examination of a wide variety of factors associated with that spending program, from its impact on employment to variation in private capital expenditures and pollution. In times of fiscal stress, however, states are much more likely to implement fiscal retrenchment measures than new spending programs. The literature on the impact and objectives of fiscal consolidation is abundant (for a survey, see Bibow, 2004; Briotti, 2005), and boomed after the Asian financial crisis of 1997. When managing episodes of fiscal

¹²⁹ Theoretically, the problem of a “balanced budget” objective function has to do with preferences. By essence, in states where there is a constitutional requirement for balanced budget, there cannot be any tradeoff between this objective and say, employment or economic growth. And if there is no tradeoff, then multiobjective optimization has no purpose being used.

retrenchment, the attention of policy makers is focused on a certain number of macroeconomic indicators, chiefly economic growth and employment. Those are tantamount to policy objectives in a multiobjective linear programming model.

HOUSEHOLDS INCOME

The typology established by Alesina and Perroti in their influential 1996 paper is useful to frame what could be relevant policy objectives for decision maker implementing budget cuts. “Type I” fiscal adjustment, which relies mostly on spending cuts – and in particular on reduction in transfers, social security and government wages and employment – appears to be the most relevant category. It is possible to associate with this type of fiscal adjustment specific policy objectives. The two authors remark that the classical Keynesian approach put heavy emphasis on how variations in wealth affect consumption (and thus growth). Budget cuts indeed reduce the government’s payroll and negatively impact households’ income. Limiting the impact of budget cuts on households is thus a policy objective. In this perspective, there is a need for us to develop a direct impact coefficient matrix for households’ income¹³⁰, such that:

$$[D^{WE}] = [D_1^{WE} \quad \dots \quad D_n^{WE}]$$

where D^{WE} denotes the total impact of the budget cuts on households’ income, and where n is the row dimension of the SAM.

¹³⁰ This reason can also be invoked to justify the use of a SAM framework over a more simple input-output model.

We may recall from our presentation of the SAM framework in Chapter III that the row vector D^{WE} can be assimilated to a sum of the elements in ΔX corresponding to the nine existing household groups¹³¹. Notice that because IMPLAN provides us with households categorized according to their income, it is actually possible to observe the income equalities that fiscal retrenchment policies may cause.

EMPLOYMENT

The biggest concern of policy makers, however, is to preserve employment. In the same manner as labor income, employment impact can be estimated through a vector of the form:

$$[D^E] = [D_1^E \quad \dots \quad D_n^E]$$

The associated objective function is specified as a maximization of the aggregate measure combining total gross output and employment. Supposing that the number of workers employed in each of the two sectors of a hypothetical economy is known, a 1×2 row vector l' of physical labor input coefficients can be created, each of its cells representing workers per dollar of output.

$$[D^E] = l' = \begin{bmatrix} \frac{E_1}{x_1} & \frac{E_2}{x_2} \end{bmatrix} = [l_1 \quad l_2]$$

¹³¹ ΔX is the vector of change in output.

where E_i is the number of workers employed in industry i . Post-multiplying this row vector by the column vector of output x provides the total employment level in the economy. Having previously demonstrated that in equilibrium $x = (I - A)^{-1}f$, pre-multiplying both side of the equation with the vector w' do not change its roots.

$$l'x = l'(I - A)^{-1}f$$

In this context, the term $l'x$ can be interpreted as the employment effect given a specific level of final demand at a prevailing technological structure captured by the Leontief inverse matrix. More importantly, it translates an output impact into an impact on the number of workers hired when a shock to the final demand vector is administered:

$$\Delta(l'x) = l'\Delta x$$

$$l'\Delta x = l'(I - A)^{-1}\Delta f$$

From this, it may be deduced that total change in output Δx is linearly related with the physical labor input coefficients. The *magnitude* of the impact of a change in final demand on employment will however differ from the *magnitude* of the impact on output if the sorted¹³² array elements of w , the transpose column vector of w' , follow a different distribution from the similarly ordered sorted array elements of the column

¹³² Ascending or descending order.

vector Δx . This condition may be expected to arise as the level of disaggregation of the SAM increases. Labor intensity is tempting to use as a basis for assessing the employment effects of a particular policy. Sectors that make extensive use of labor – and in particular unskilled labor – are not necessarily those which will yield the highest change in output when they are shocked through a modification of final demand. Intuitively, one may also anticipate that these labor-intensive sectors will be the primary drivers of job creation.

In a social accounting matrix general equilibrium framework where capital is endogenously determined, one must however take into account the indirect effects generated by a given shock. When considered endogenous, capital is indeed an intermediate input whose increased production leads to a higher demand for labor. This can be generally argued to be the case in the long-run (Galenson and Leibenstein, 1955; Sen, 1965; Morley and Kumar, 1989). Because our model deals with the short-run effects of budget cuts on a state economy, the idea of payments to capital as a leakage for job creation is more attractive though. Furthermore, state governments usually implement budget cutbacks in a context of economic crisis, when excess capacity is pervasive. As such, capital should be considered an exogenous variable in our model, and a case can be made that in the short term cushioning the negative impact of fiscal austerity on employment is not necessarily an objective consistent with gross output maximization.

ECONOMIC GROWTH

The government might also be interested in protecting the level of economic activity in the state, as reflected by variation in gross output. This feature figures prominently in social accounting matrices, and is found on the right-hand side of the framework under its planning form. It is possible to transform this measure of change in economic activity to a growth rate:

$$g = 100 \left(\frac{(Total\ Output + \Delta X) - Total\ Output}{Total\ Output} \right)$$

where *Total Output* is New York State's gross regional product before the model is shocked. The result g is however difficult to interpret. Indeed, it might be understood that g represents a growth rate over a specific period of time and can thus be readily compared with macroeconomic indicators decision makers are accustomed to (for instance the yearly or quarterly growth rate). This is not the case however, as g denotes the *instantaneous* percentage change in gross output from one state of equilibrium to the other. In such circumstances, it turns out that thinking in monetary terms may actually be preferable.

PRESERVATION OF THE TAX BASE

With these three objectives in mind (employment, labor income and growth), it is possible to brush aside the preservation of tax revenues as a policy objective since it can be argued that the tax base is overwhelmingly determined by the (i)

unemployment rate, (ii) households' income and (iii) the economic activity of the private sector (Rao, 1979). By optimizing these three objectives, the tax base should be optimized as well.

OTHER OBJECTIVES

Besides labor income, output and employment, policy makers can be interested in limiting the negative impact of their policies on private investment and capital formation. This, however, cannot be captured in the SAM framework. Nor can variations in economic productivity, except if a series of posterior social accounting matrices could be found for New York State (Miller and Blair, 2009).

Another potentially important policy objective identified by Alesina and Perotti is the so-called credibility effect¹³³. It could be important for states owing large stocks of debt or for those which must refinance a consequent portion of their outstanding debt in the months that directly follow the episode of mid-year budget cuts. The theory is that the better the management of fiscal adjustments, the larger the impact on interest rates. The argument, although intensely debated among economists, does not hold for New York State. The interest rate could be swapped for the interest on municipal bonds but up to our knowledge there is no study establishing a clear link between budget deficits, fiscal retrenchment and the market performance of “munis”. Johnson and Kritz (2005) found evidence that some institutional factors – expenditure limits,

¹³³ Paul Krugman, a detractor of the idea, repeatedly assimilated the concept to that of a “confidence fairy” in his New York Times' editorials.

balanced budget requirements and restrictions on debt issuance – are correlated with lower borrowing costs through better credit ratings, but they are by essence irrelevant to short term management of fiscal deficits. The credibility effect will be ignored in this dissertation.

Of course, it is possible to add objective functions *ad infinitum*. It may be particularly interesting to complete the purely socio-economic objective functions we just described by a set of political criteria. A governor, for instance, might rely on a body of constituents he wishes not to alienate. In such a case, reducing as much as possible the amount of budget cuts asked to a specific program could well be considered a valid criterion. But each additional objective function comes at a technical and computational cost¹³⁴.

5.4.4 Mathematical Formulation of the Problem

For the purpose of this dissertation, we feel that a simple focus on three economic variables, employment, labor income and growth is sufficient. The SAM model presented above allows us to express the criteria as functions of the policy instrument vector. The social accounting matrix multiobjective linear programming model for New York State can be written as follow¹³⁵:

¹³⁴ For example, the augmented weighted Tchebycheff procedure described in Chapter III is less effective when the number of objective functions considered is larger than 3.

¹³⁵ The superscript prime of a vector indicates it is a row vector.

Objective functions:

$$\text{Max } Z_1 = [D^E]'[L_{ij}][x_j]$$

Employment (a scalar¹³⁶)

$$\text{Max } Z_2 = [D^{WE}]'[L_{ij}][x_j]$$

Labor income (a scalar)

$$\text{Max } Z_3 = [L_{ij}][x_j]$$

Economic growth (the summation of a column vector)

$$\text{where } [L_{ij}][x_j] = [X]$$

Constraints:

$$\text{subject to } 0.85x_t \leq x_t \leq 1.15x_t \quad \forall t$$

$$\sum_{t=1}^6 x_t = BG$$

$$x_j = 0 \quad \forall j \notin \{t\}$$

$$x_j \geq 0 \quad \forall j$$

Notice that because the feasible region of this particular problem is located in the bottom-back-left $(-, -, -)$ octant of the R^3 Euclidean three-dimensional coordinate system¹³⁷ used to represent graphically the criterion space¹³⁸, the optimization problem is actually one of maximization and not one of minimization, as we may intuitively think. This is because it is better to achieve a loss of ten jobs than the loss of a hundred jobs $(-100 < -10)$.

¹³⁶ Notice the dimensions. Multiplication of these matrices will result in a scalar.

¹³⁷ In the familiar R^2 Euclidean two-dimensional space, the problem would be located in the third quadrant.

¹³⁸ The decision space cannot be represented graphically, as it is a convex 6-polytope. Convexity derives from the purely linear characters of social accounting matrices and their attached total direct-impact coefficient vectors.

5.5 Results

5.5.1 The Set of Pareto Optimal Policies

As illustrated in Chapter III, it is always beneficial to begin the solution of a multiobjective program by computing a payoff matrix. Through the payoff matrix we will be able to identify an ideal point from which the algorithm will start investigating the feasible region and a Nadir point which will bind the research of the algorithm¹³⁹. The tables presented hereunder display the values taken by the different objective functions when they are optimized individually, i.e. notwithstanding other criteria. It can be seen immediately that optimizing output and employment separately reaches the same result. This is probably an effect of the IMPLAN matrix theoretical framework, which instead of econometrically or statistically calibrating the employment multipliers simply postulate a linear ordered relationship with output multipliers.

We may consequently eliminate either employment or output because they are not contradicting criteria. The employment objective function is removed from the model, enabling us to get rid of a cumbersome vector of direct impact. Interestingly enough, we observe that taxes appear to be conflicting with both labor income and output. It will be included in the final model, since it can be argued that a fiscal retrenchment strategy sabotaging tax revenues would be self-defeating. From now on, we will thus

¹³⁹ The model is solved using the 2007 version of the Excel Solver add-in.

assume that Z_I corresponds to tax, while the two other criterion vectors remain unchanged, so that:

$$Max Z_1 = [D^{IBT}]' [L_{ij}] [x_j]$$

It is also noteworthy that in the perspective of a single objective linear programming optimization and no matter what objective is selected, the Deficit Reduction Plan is always non optimal in equilibrium. Indeed, the Simplex algorithm used by Excel to solve the program picks up room for improvement by proposing an entirely different set of values for the decision variables. This implies that with respect to monobjective programming, the Deficit Reduction plan consists in a set¹⁴⁰ of dominated solutions. However, this might simply be the result of the existence of multiple conflicting objectives the Governor wished to accomplish.

It is instructive to record the equilibrium values taken by the different policy objectives when the Deficit Reduction Plan is implemented (we will come back to it more thoroughly in section 5.6 hereunder):

$Z_1 \approx -1,356,003$	indirect business tax
$Z_2 \approx -9,673$	labor income
$Z_3 \approx -10,522$	total output

When compared with the results obtained from individual optimization presented in table 5.9, one can clearly see why the Deficit Reduction Plan is an inefficient fiscal

¹⁴⁰ By set, we mean the collection of all Z vectors optimized individually.

retrenchment policy for New York State. If the Governor's objectives were limited to a strict minimization of the negative impact of his policy on aggregate output, then it would be possible to contain the contraction of the state's GRP to -1.024% instead of -1.029%. In dollar terms, this represents saving \$55 million or 3.1% of the total budget cuts. This policy however leads to a larger decrease in labor income (\$9.714 billion against \$9.672 billion), even though it performs better from the perspective of the indirect business tax. The same demonstration holds for every objective, which steers us toward the conclusions that:

- (i) there exists a conflict between the three objectives, as none of the optimized solution vectors simultaneously dominate the others with respect to all objectives (i.e. all are non-dominated);
- (ii) the Deficit Reduction Plan is not optimal in the Pareto sense.

In order to achieve the highest level of growth possible, it appears that the decision maker should redistribute the budget cuts in favor of the state agencies and local governments and to the detriment of health care and transportation. The same holds true for employment. On the other hand, if the decision maker prefers to protect labor income, she should emphasize cuts in education and governmental functions while preserving health care and transportation. Finally, a pro-tax revenue fiscal retrenchment strategy would privilege non-education programs and transportation over elementary/secondary education and health care.

Table 5.5. Optimization of aggregate output (\$ in millions)

CONSTRAINTS				CELL	OPTIMIZED	ORIGINAL
1. Budget cut target constraint	-1784,7	=	-1 784,7			
	Lower bound		Upper bound			
2. Total State and Local Non-education	-668,1	-786	-903,9	B84	-780,3	-786
3. School Aid	-408,3	-480,3	-552,3	B85	-408,3	-480,3
4. Health Care Non-hospital	-167,0	-196,5	-226,0	B76	-226,0	-196,5
5. Health Care Hospitals	-167,0	-196,5	-226,0	B77	-226,0	-196,5
5. Transportation	-106,6	-125,4	-144,2	B64	-144,2	-125,4
				Total	-1784,7	-1784,7

Table 5.6. Optimization of Employment

CONSTRAINTS				CELL	OPTIMIZED	ORIGINAL
1. Budget cut target constraint	-1784,7	=	-1 784,7			
	Lower bound		Upper bound			
2. Total State and Local Non-education	-668,1	-786	-903,9	B84	-780,3	-786
3. School Aid	-408,3	-480,3	-552,3	B85	-408,3	-480,3
4. Health Care Non-hospital	-167,0	-196,5	-226,0	B76	-226,0	-196,5
5. Health Care Hospitals	-167,0	-196,5	-226,0	B77	-226,0	-196,5
5. Transportation	-106,6	-125,4	-144,2	B64	-144,2	-125,4
				Total	-1784,7	-1784,7

Table 5.7. Optimization of Labor Income (\$ in millions)

CONSTRAINTS				CELL	OPTIMIZED	ORIGINAL
1. Budget cut target constraint	-1784,7	=	-1 784,7			
	Lower bound		Upper bound			
2. Total State and Local Non-education	-668,1	-786	-903,9	B84	-903,9	-786
3. School Aid	-408,3	-480,3	-552,3	B85	-440,2	-480,3
4. Health Care Non-hospital	-167,0	-196,5	-226,0	B76	-167,0	-196,5
5. Health Care Hospitals	-167,0	-196,5	-226,0	B77	-167,0	-196,5
5. Transportation	-106,6	-125,4	-144,2	B64	-106,6	-125,4
				Total	-1784,7	-1784,7

Table 5.8. Optimization of Indirect Business Tax (\$ in millions)

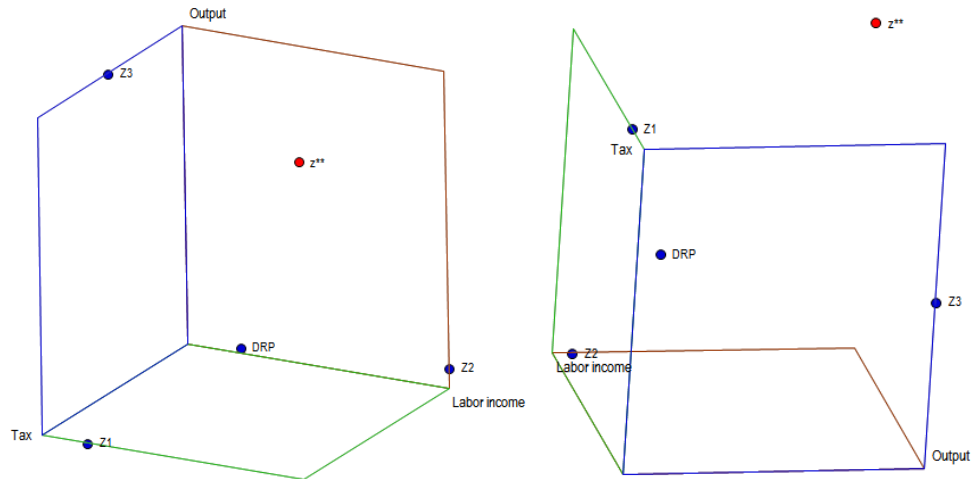
CONSTRAINTS				CELL	OPTIMIZED	ORIGINAL
1. Budget cut target constraint	-1784,7	=	-1 784,7			
	Lower bound		Upper bound			
2. Total State and Local Non-education	-668,1	-786	-903,9	B84	-668,1	-786
3. School Aid	-408,3	-480,3	-552,3	B85	-552,3	-480,3
4. Health Care Non-hospital	-167,0	-196,5	-226,0	B76	-226,0	-196,5
5. Health Care Hospitals	-167,0	-196,5	-226,0	B77	-226,0	-196,5
5. Transportation	-106,6	-125,4	-144,2	B64	-112,3	-125,4
				Total	-1784,7	-1784,7

The payoff matrix is presented below. The first row records the values for all three criterions when the policy maker aims at minimizing the loss in indirect business tax revenues only. The second row and third row present the criterion values for labor income maximization and output/employment maximization respectively. The coordinates of the ideal point in the R^3 three-dimensional Euclidean criterion space are found on the diagonal of the payoff matrix.

Table 5.9. Payoff matrix

	Tax (τ)	Labor income (ω)	Output (γ)
Max $Z_1 = \tau$	-1,161,526.7	-9,714.0	-10,535.7
Max $Z_2 = \omega$	-1,547,919.5	-9,602.6	-10,531.2
Max $Z_3 = \gamma$	-1,349,004.3	-9,737.1	-10,465.8

Figure 5.3. Two 3-D scatter plots of the solution vectors (monobjective optimizations)



The policy implications of the tradeoffs presented in the table above are difficult to draw without knowing the preferences of the policy maker. Indeed, no fiscal retrenchment strategy ends up hurting significantly one criterion to boost another. Perhaps in these circumstances alternatives could be judged *a priori* similar, and the analyst could limit herself to a monobjective linear program of the kind we just solved. It seems however to us that given the variations in ω , the tax revenues, any decision maker with even a slight interest in this objective may find a strategy where the stress is put on labor income undesirable.

5.5.2 Algorithms

A solution to this problem, the simplest one, is to transfer the original multiobjective linear program to a goal programming framework (Charnes, Cooper and Ferguson, 1955; Charnes and Cooper, 1961; Jones and Tamiz, 2010). In this case, a preferred objective usually referred to as the achievement function would be optimized, while the other objective functions would be converted to constraints. These constraints take the form of target levels under which the value of the former objectives must not fall¹⁴¹. The concept behind goal programming is to obtain the best value for one objective, for instance labor income, while the others are constrained parametrically. This method is illustrated hereunder.

It is by no means the only one available however, as we have seen in chapter III. In particular, evolutionary multicriterion optimization offers a very powerful instrument to solve large scale economic models such as a disaggregated SAM. They are indeed capable of meeting efficiently two of the most important requirements of multiobjective optimization (Deb, 2001):

- (i) finding a pool of solutions as close as possible to the Pareto front;
- (ii) finding a pool of solutions as diverse as possible.

Evolutionary algorithms (EAs), including genetic algorithms, have three principal characteristics (Tan, Khor and Lee, 2005):

¹⁴¹ For an example of input-output model combined with goal programming, see chapter 10 in Miller and Blair (2009).

- They are **population-based**, in the sense that they maintain a set of solutions called a *population*;
- They are **fitness-oriented**, as they assign a gene representation (called a *code*) and an estimate of performance (the *fitness value*) to each member (the *individuals*) of the solution set. The fitness orientation of evolutionary algorithms is what drive the optimization process and enables programs to converge to a solution, as EAs are based on a Darwinian “survival of the fittest” principle;
- They are **variation-driven**, because the codes of the individuals belonging to the set of feasible solutions are allowed to mutate.

Among evolutionary algorithms, Tan, Khor and Lee (2005) find that those incorporating elitism¹⁴² tend to outperform others when it comes to convergence and the revelation of the Pareto front. This superior performance is however achieved at a computational cost.

AN ELITIST GENETIC ALGORITHM: NSGA-II

The original method adopted to solve the three-dimensional multiobjective optimization problem was the Non-dominated Sorting Genetic Algorithm II (NSGA-II), a genetic algorithm based on non-dominated sorting (Deb et al., 2000). The principle of genetic algorithm is relatively simple: it maintains a population of

¹⁴² For example the Pareto Archived Evolution Strategy (PAES), the Pareto Envelope-based Selection Algorithm (PESA), the Non-dominated Sorting Genetic Algorithm II (NSGA-II), the Strength Pareto Evolutionary Algorithm 2 (SPEA2), IMOEa and CCEA.

chromosomes (solutions) from which it selects, mutates and crossovers¹⁴³ according to parameters chosen by the analyst. The larger the population of chromosomes the algorithm can pool from, the more computationally intensive the program¹⁴⁴.

The genes in the genetic algorithm are formed by the decision variables, which taken together create the chromosomes and thus the set of optimal solutions. Thanks to a mutation rate determined by the analyst, NSGA-II is able to escape locally Pareto optimal solutions and can converge to global optimums scattered across the tradeoff surface. Mutation is operated at random on one of the genes composing a chromosome, and the new value taken by the chromosome is itself determined randomly within the constraints of the gene.

Solutions are then classified according to the so-called method of the “crowded tournament”, where a set of solutions is chosen at random from the population and ordered. The concept of the “crowded tournament” is based on a measure of density which takes the average distance of two individuals on either side of another individual along each of the objectives. But this measure of density comes second in importance to the rank value assigned to each individual by the fast nondominated sorting component of the algorithm.

¹⁴³ Crossover designates the chromosome splicing procedure through which the algorithm spread information between individuals to create new solutions that reproduce some of the attributes of their parents.

¹⁴⁴ The overall complexity of the algorithm is dependent on both the population size and the number of policy objectives.

The mechanics of the NGSA-II algorithm are easier to understand once its general structure is presented. An overview of the main features of the NGSA-II is provided by Tan, Khor and Lee (2005:24) and is reproduced hereunder:

```

Initialize generation counter:  $n = 0$ .
Create a parent population,  $Ppop$  of size  $P$ .
Initialize offspring population as  $Opop = []$ 
Repeat while stopping criterion is not met.
     $Cpop = Ppop \cup Opop$ .
     $rank = \text{FNDomSort}(Cpop)$ .
    Function (rank) = FNDomSort( $Pop$ )
        Repeat for each solution  $i$  in  $Pop$ .
             $n_i$  is the number of solutions dominating the individual  $i$ .
             $S_i$  is a set of individuals dominated by individual  $i$ .
        End Repeat
         $Q$  = set of individuals in  $Pop$  with  $n_i = 0$ .
         $CurRank = 0$ .
        Repeat while  $Q$  is not  $[]$ .
             $R = []$ .
             $CurRank = CurRank + 1$ .
            Repeat for each individual  $i$  in  $Q$ .
                 $rank(i) = CurRank$ .
                Repeat for each solution  $j$  in set  $S_i$ .
                     $n_j = n_j - 1$ .
                    If  $n_j = 0$ 
                        Put individual  $j$  in  $R$ .
                    End If
                End Repeat
            End Repeat
             $Q = R$ .
        End Repeat
    End Function
    Return (rank).

 $Ppop = []$ .
 $rankP$  = the rank value of the  $P$ th individual in  $Cpop$  sorted in ascending order of
rank.

 $Ppop$  = individuals from  $Cpop$  with the  $rank < rankP$ .
 $Ppopsize$  = number of individuals in  $Ppop$ .
 $Tpop$  = individuals from  $Cpop$  with rank value of  $rankP$ .
 $CDtc = \text{CrwdDA}(Tpop)$ .
Function ( $CDtc$ ) = CrwdDA( $Pop$ )
     $F(i,j)$  = the normalized  $j$ th objective function of individual  $i$  in population

```



```

    Pop.
     $f_j^{max} = \max (F(i, j): \forall i = 1, 2, \dots, P)$ .
     $f_j^{min} = \min (F(i, j): \forall i = 1, 2, \dots, P)$ .
     $P$  = number of individuals in Pop.
     $CDtc(i) = 0, \forall i = 1, 2, \dots, P$ .
    Repeat for each objective  $j$ .
         $Idx$  = index vector based on the sorting of vector  $(F(i, j): \forall i = 1, 2, \dots, P)$ .
         $CDtc(Idx(1)) = CDtc(Idx(P)) = \infty$  .      % Boundary points are
        always selected
        Repeat for each individual  $i$  from 2 to  $(P - 1)$ .
             $CDtc(Idx(i)) = CDtc(Idx(i)) +$ 
             $[F(Idx(i+1), j) - F(Idx(i-1), j)] / (f_j^{max} - f_j^{min})$ .
        End Repeat
    End Repeat
    Return ( $CDtc$ ).
End Function
Ppop = Ppop  $\cup \{(P - Ppopsize)$  individuals with the largest  $CDtc\}$ .
Opop = genetic_operators(Ppop).
 $n = n + 1$ .
End Repeat
Return (Ppop, Opop, ...).

```

Ppop, the randomly generated parent population forms the basis of the loop that will converge through the “crowded tournament” method to a set of Pareto optimal solutions. It generates itself in the first generation ($n=0$). This parent population is then combined to an offspring population *Opop* (which in an empty set at $n=0$) to form a new population denoted *Cpop*. The individuals of *Cpop* are then compared ranked according to a fast nondominated sorting function $FNDomSort(Cpop)$. The individuals who made the cut are then reintegrated into a new *Ppop* population of size P . The crowding distance assignment function $CrwdDA(TPop)$ is then used before genetic operators are applied on the resulting population *Ppop*, which is actually the parent population at the beginning of the second generation ($n=1$). The loop creates from *Ppop* a non-empty offspring population *Opop*, while the statement **#Repeat** while

stopping criterion is not met. # ensures that the algorithm repeats the process from generation to generation up until a predetermined limit is met. This limit is usually put on the number n of generations the algorithm can create.

The implementation of a genetic algorithm is both complex and computationally intensive, especially when there are more than two objective functions. Using the free SolveXL¹⁴⁵ add-in for Microsoft Excel, it is possible to obtain a taste of an optimization process using the NGS II genetic algorithm. Unfortunately, the software does not support more than two objective functions and thirty decision variables, which is well under the requirements of a model as large as ours. Consequently, the algorithm is run for two objectives only: output – and by extension employment – and labor income. It is possible to adjust the model to fit these criteria through a series of manipulation, but we quickly run into the difficulty of customizing the constraints.

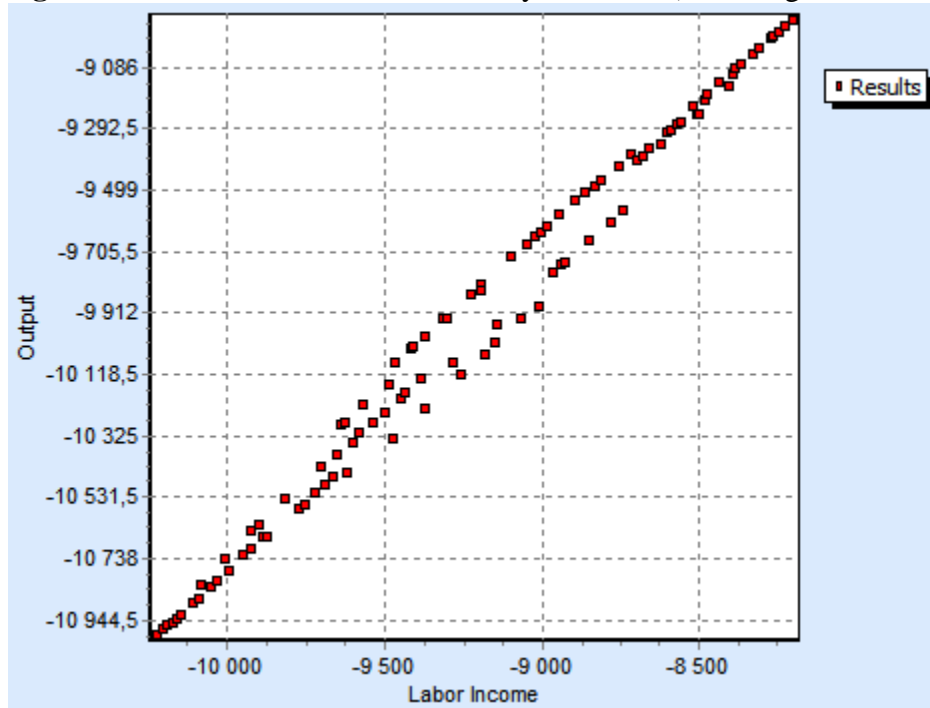
We partially overcame the problem by imposing strong penalties to the two objective functions selected when they deviate significantly from the overall target of budget cuts. It is insufficient though. Indeed, after 200 generations the model still fails to converge to an optimal solution respecting the constraint of realizing \$1.78 billion in spending reduction measures. It actually falls short of \$136 million, or 7.64%. The source of the problem clearly lies in the definition of the constraints, and can be solved

¹⁴⁵ <http://www.solvexl.com/>

only by implementing the algorithm in MATLAB or in the C programming language¹⁴⁶.

The set of solutions determined by NGSA II is graphically represented hereunder. The optimal solution in this configuration has the coordinates (-9,003.3 , -9,639) in the criterion space for a total budget cut value of \$1.65 billion.

Figure 5.4. Set of solution determined by NGSA II (including non feasible solutions)



Note: Simple one point with crossover rate: 0.95; simple mutator with mutation rate: 0.3; 200 generations; integer bounded genes

¹⁴⁶ It would also be possible to re-integrate the third objective function.

CONSTRAINT PROGRAMMING

Without a professional solver software, it is difficult to attempt to solve a problem like ours through a genetic algorithm. The same difficulty exists when it comes to constraint programming, although the technique is more tractable. To facilitate the discovery of the Pareto front, we will drop of the model one of the objective function, namely tax.

Objective functions:

$$\text{Max } Z_1 = [D^{WE}][L_{ij}][x_j]$$

Labor income

$$\text{Max } Z_2 = [L_{ij}][x_j]$$

Economic growth / Employment

$$\text{where } [L_{ij}][x_j] = [X]$$

Constraints:

$$\text{subject to } 0.85x_t \leq x_t \leq 1.15x_t \quad \forall t$$

$$\sum_{t=1}^6 x_t = BG$$

$$x_j = 0 \quad \forall j \notin \{t\}$$

$$x_j \geq 0 \quad \forall j$$

The set of nondominated solutions is then constructed by transforming output into a constraint. Labor income is then maximized using the Simplex algorithm. The optimization consists in achieving the smallest loss in total labor income with the minimum impairment to economic growth (the change in aggregate output). The payoff matrix for such a problem is different from the one presented in table 5.9:

Table 5.10. The payoff matrix for a two-objective constraint program

	Labor income (ω)	Output (γ)
Max $Z_2 = \omega$	-9,602.6	-10,531.2
Max $Z_3 = \gamma$	-9,737.1	-10,465.8

As for the mathematical optimization model, it is re-written to accommodate constraint programming:

Objective functions:

$$\begin{aligned} \text{Max } Z_1 &= [D^{WE}]' [L_{ij}] [x_j] && \text{Labor income} \\ \text{where } [L_{ij}] [x_j] &= [\Delta X] \end{aligned}$$

Constraints:

$$\begin{aligned} \text{subject to } [L_{ij}] [x_j] &\geq [\Delta X_\gamma] && \text{Economic growth / Employment} \\ 0.85x_t &\leq x_t \leq 1.15x_t \quad \forall t \\ \sum_{t=1}^6 x_t &= BG \\ x_j &= 0 \quad \forall j \notin \{t\} \\ x_j &\geq 0 \quad \forall j \end{aligned}$$

where ΔX_γ is a minimal achievement value for the change in aggregate output set by the decision maker (and by extension represents the variation in employment, by virtue of the construction of the IMPLAN data set).

The best way to approximate the behavior of the solution set is to create a scatter plot recording the value of the change in output expressed as a function of maximized labor income on a range that respect the $[L_{ij}] [x_j] \geq [\Delta X_\gamma]$ constraint. This range is bounded by the figures found in the second column of the payoff matrix 5.10: the decision maker can set the maximal tolerable output loss to be everywhere between \$10.53 billion at worse and \$10.46 billion at best, the two extreme boundaries values taken by output still belonging to the set of feasible solutions S . In the former case, the decision maker actually does not care about output growth whereas in the latter case, she displays a strong bias toward achieving the best value for output. The graphical representation of the Pareto front will thus span an interval covering \$65.4 million in output. The same logic holds true for labor income, although the interval is far larger

(\$134.5 million) and the value of labor income itself is determined by the Simplex algorithm, not the decision maker.

$$\therefore -10,531.2 \lesssim [L_{ij}][x_j] \equiv [\Delta X_\gamma] \lesssim -10,465.8$$

$$\therefore -9,737.1 \lesssim [D^{WE}][L_{ij}][x_j] \lesssim -9,602.6$$

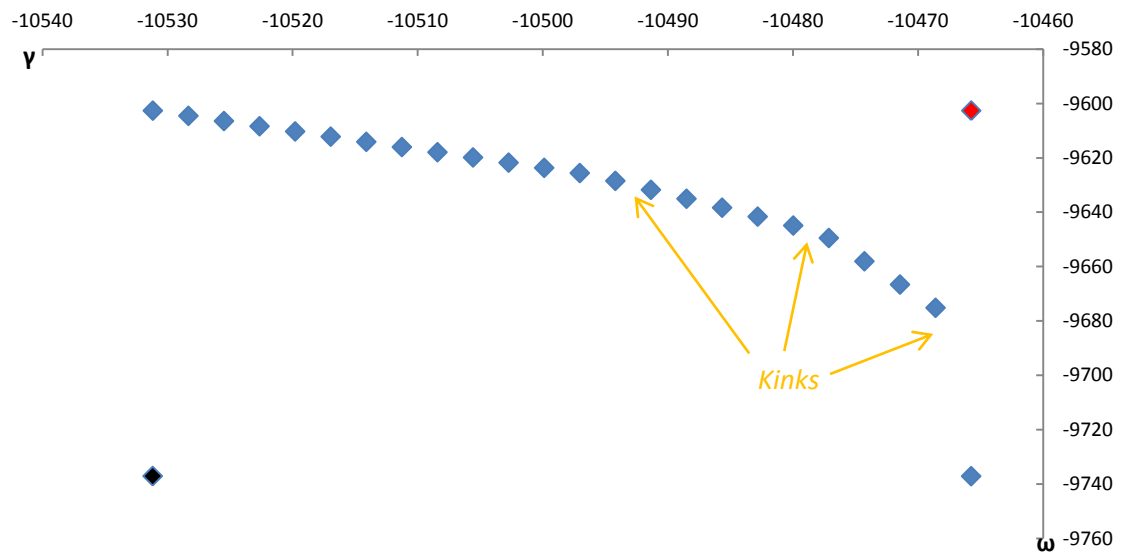
Twenty-three points $\Delta X_\gamma^0 \rightarrow \Delta X_\gamma^{22}$ have been computed, a number that is large enough to provide a good approximation of the Pareto front. From figure 5.4 hereunder we see that the relationship between labor income and output is monotonic and strictly decreasing: the smaller the overall loss in labor income, the larger the contraction of the gross regional product and of employment. This is of course expected if we want our¹⁴⁷ problem to be non-trivial.

Another insight we gain from figure 5.4 is that the Pareto front is non-linear, i.e. the slope of the efficient frontier is not constant. The steepness of the Pareto front's slope appears particularly high for lower values of labor income, before going through three “kinks” and stabilizing to a quasi-linear state. This implies that the Governor must be willing to sacrifice a larger and larger amount of labor income to target higher levels of output growth or employment. Put into the wording of an economist, the marginal cost of economic growth / employment in terms of labor income is increasing (and at

¹⁴⁷ Monotonicity and a decreasing relationship are not necessary for a goal programming problem to be non-trivial. For instance, a state office in charge of energy might deem that increased electrical output from a new dam project is beneficial, but that land flooding is nefarious. Assuming a positive correlation between the area flooded and electrical output, one can see that two variables can have a positive relationship without the problem becoming trivial.

an increasing rate). Because the marginal cost is such an important part of decision making in economics, being able to identify kinks on the Pareto frontier is crucial. Hence the importance of the quality of the algorithm used to solve the multiobjective program, and in particular its ability to sample at regular intervals the set of non-dominated solutions and its ability to circumvent local optima.

Figure 5.4. The Pareto front for a two-objective fiscal retrenchment problem in New York State



Note: The ideal vector z^{**} is in the upper right corner, in red. The Nadir point is located in the lower left corner, in black.

The absence of a vertical segment on the Pareto frontier means that it is not possible to improve one objective without sacrificing the other. The slope of the Pareto front, by capturing the marginal cost of growth in terms of labor income, thus represents the policy trade-off that the Governor of New York State faces when designing his mid-year budget cuts. The two policy objectives in presence being output/employment and labor income, the slope can be interpreted as the rate at which the decision maker

should be willing to “trade” a lesser level of employment for an increase in the revenue available to households.

5.6 Policy Design

The definition of the Pareto front marks the first step of the analysis of mid-year budget cuts in New York State. The second step actually involves the production of some macroeconomic (or econometric, or at best both) estimates of the impact of the policy choices previously established by the decision maker. In our case, the social accounting matrix model under its impact form should be run for the Deficit Reduction Plan, so as to gain an understanding of the whereabouts of the policy in the criterion space, and how far it is from the Pareto front. Put it simply, we want to gain an understanding of the performance of the Deficit Reduction Plan by running it through the Walrasian general equilibrium framework. Having accomplished this, its efficiency can be assessed with regards to our own findings.

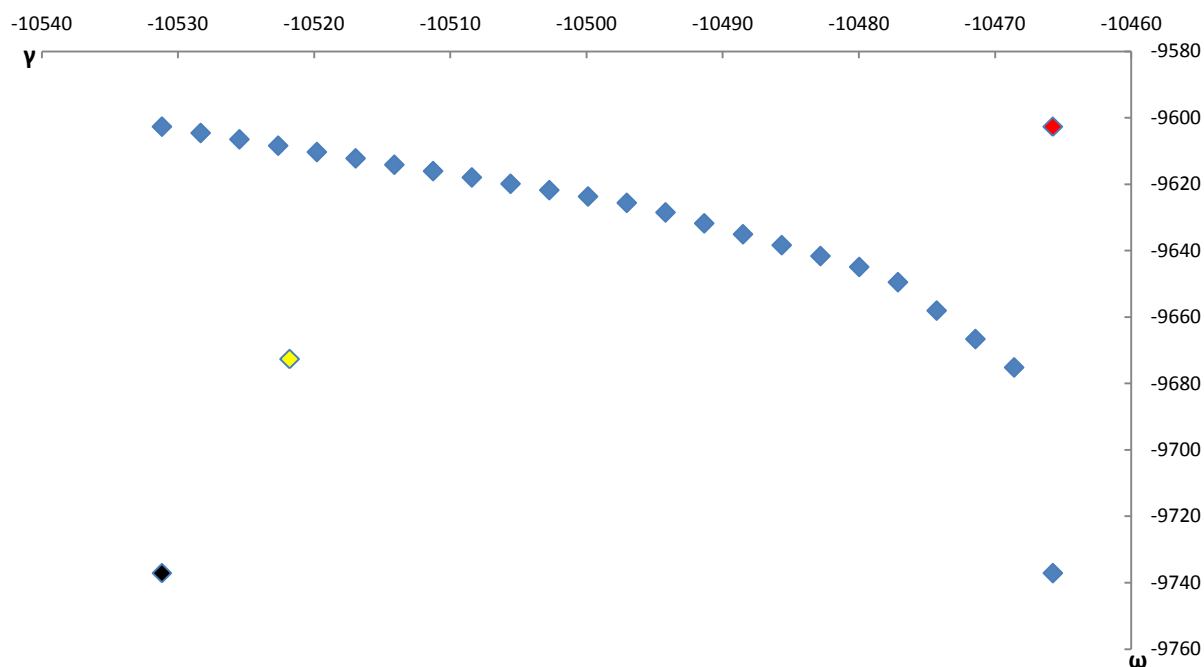
The general equilibrium impact of the Deficit Reduction Plan is estimated below:

$$\gamma = -10,521.8$$

$$\omega = -9,672.6$$

Those are its coordinate in the criterion space.

Figure 5.6. Graphical representation of the Deficit Reduction Plan in the criterion space



Note: The DRP vector is the yellow point.

The vector representing the Deficit Reduction Plan is clearly located in the set of dominated solutions vis-à-vis the two objectives of interest. Using the SAM-MOLP model to distribute the mid-year budget cuts among programs, it is possible to improve the value of labor income by 0.66%, or \$63.7 million, with the same contraction of the gross regional product. Keeping labor income constant, the efficiency of budget cuts with respect to output would increase by 0.5%, or \$52.4 million.

Policy inefficiencies could be corrected by moving closer to the Pareto front, which gathers a set of Pareto optimal budget retrenchment vectors. In order to do so, the policy maker must agree to bring significant modifications to the repartition of the

budget cuts among programs. Again, it should be forcefully emphasized here that if a change can translate into improved economic efficiency, it might not be politically feasible. Assuming it is we must fall back to the yet unused decision space to investigate the nature of the modifications that should be carried out. Indeed, if the criterion space provides the decision maker with the direction she ought to steer her policy toward, the helm is to be found in the decision space.

This constant navigation between criterion space and decision space is a prominent feature of multiobjective optimization. Having a sense of the set of non-dominated solutions is indeed of little help to the decision maker if these esoteric concepts cannot be spelled out in terms of concrete policy instruments. The following table is employed to this use:

Table 5.11. Toward optimality: a schedule for policy instruments (\$ in millions)

Program	Budget cut size		
	DRP	Pareto optimal reference	Change (%)
Education	-480.3	-408.3	-15.0%
Non-education	-786	-874.6	11.3%
H/C Non-hospitals	-196.5	-167	-15.0%
H/C Hospitals	-196.5	-226	15%
Transportation	-125.4	-108.8	-13.2%

Note: The “Pareto optimal reference” was selected at random among the set of non-dominated solutions.

It is interesting to note that the reference selected leads to considerable changes in the distribution of the budget cuts given the set of established constraints. Four programs actually converge to their boundaries ($\pm 0.15x_t$): education, health care non-hospitals,

health care hospitals and transportation. Every single area experiences a change of at least 10% in the amount of budget cuts they are expected to implement. This is perhaps not surprising considering that the basis of our optimization program is a social accounting matrix. Due to the fixed multipliers nature of the SAM, the Simplex algorithm indeed exhausts first the programs that lead to the fastest increase in Z_I , the labor income. That is, it moves from adjacent corner point feasible (CPF) solution to adjacent CPF solution using the steepest edges of the feasible region up until it hits a new constraint boundary¹⁴⁸.

5.7 Policy recommendations

Since the purpose of any policy in the theory of “distance-to-a-reference-objective” is to get as closely as possible from the ideal point z^{**} while respecting the set of constraints $x \in S \rightarrow z \in Z$, policy recommendations derived from our model would include a complete overhaul of the Deficit Reduction Plan. It appears that the magnitude of the divergence between the Pareto optimal reference we selected and Governor Paterson’s Deficit Reduction Plan, *with respect to output/employment and labor income*, is abysmal, denoting a high degree of economic inefficiency in the proposed budget cuts.

¹⁴⁸ The geometrical procedure is more complex because the decision space has five dimensions. The Simplex algorithm investigates a 5-polytope where CPF solutions are vertices and edges are bounding Polychoron facets.

Table 5.12. Economic benefits gained through constraint programming optimization (\$ in billions)

Objective	Budget cut size		
	DRP	Pareto optimal reference	Difference
Output/Employment	-10,521.8	-10,477.1	0.0447
Labor income	-9,672.6	-9,649.5	0.0231

According to the social accounting matrix multiobjective linear programming model developed in this chapter, optimization of the fiscal year 2009 mid-year budget cuts could have resulted in a \$44.7 million increase aggregate output and \$23.1 million more in labor income throughout the state's economy in equilibrium. The figures might seem small in comparison of the size of the economy of New York State. But the state's economy shrunk by \$30.3 billion in 2009, or \$7.5 billion on a quarterly basis, according to data from the Bureau of Economic Analysis. Assuming that the effects of an optimized deficit reduction plan would have taken place during the last quarter of 2009, the economy would have performed 0.6 percentage point better. Because the impact of mid-year budget cuts on the economy tends to manifest itself rapidly, such gains in efficiency are, we believe, worth investigating further.

Moreover, the highly aggregated level of the social accounting matrix may actually cause the model to perform less well than it could. Indeed, if more programs could be included and if a difference could be made between the activities of the state and local governments the ensuing granularity would allow the Simplex algorithm to play on more policy instruments. It is possible – even likely – that some of these instruments would improve the policy objectives at a faster rate than the one we used.

In terms of the program affectation of budget cuts, the policy schedule presented above indicates that three areas, ‘education’, ‘health care non hospitals’ and ‘transportation’ have to shoulder too heavy a burden in the Deficit Reduction Plan. This would constitute the low-hanging fruits of efficiency that can be easily reaped by marginally decreasing the contribution of these programs to the overall fiscal retrenchment policy. On the other hand, it appears that ‘state and local governments non-education’ as well as ‘health care hospitals’ can be required to realize more savings.

This may be touching to a limit of our model. The study of mid-year budget cuts by themselves is possible because their sizes are typically sufficiently small compared to a regional economy to allow the assumption that prices are fixed and that production is characterized by a Leontief economy without returns to scale or input substitutions. However, it is highly unlikely that such sectors as ‘education’ and ‘hospitals’ have not been already asked for significant downsizing in the period preceding the apparition of the mid-year deficit. Once again, we come back to the idea – which has been pervasive in this chapter – that the definition of the constraints in the linear program, or what is economically, socially and politically feasible, is perhaps the single most critical factor in the elaboration of an optimization model. To quote Otto von Bismarck, “Die Politik ist die Kunst des Möglichen”: Politics is the art of the possible.

5.8 Adding Policy Objectives

5.8.1 An Extended Model Including Employment and Tax

In order to simplify the demonstration and provide clear graphical illustrations of a practical application of the social accounting matrix multiobjective linear programming model, we have eliminated in the previous section one of the three objective functions initially identified: the indirect business tax. Even before that, we argued that optimizing aggregate output and optimizing employment were fully consistent and that one could be safely removed from the model. For the sake of demonstration, it is now re-integrated.

The extended SAM-MOLP thus includes four policy objectives: labor income ω , output γ , unemployment v and indirect business tax θ .

Objective functions:

$Max Z_1 = [D^E]'[L_{ij}][x_j]$	Employment (v , a scalar)
$Max Z_2 = [D^{WE}]'[L_{ij}][x_j]$	Labor income (ω , a scalar)
$Max Z_3 = [L_{ij}][x_j]$	Economic growth (γ , the summation of a column vector)
$Max Z_4 = [D^{IBT}]'[L_{ij}][x_j]$	Indirect business tax (τ , a scalar)
where $[L_{ij}][x_j] = [X]$	

Constraints:

$$\begin{aligned} \text{subject to } & 0.85x_t \leq x_t \leq 1.15x_t \quad \forall t \\ & \sum_{t=1}^6 x_t = BG \\ & x_j = 0 \quad \forall j \notin \{t\} \\ & x_j \geq 0 \quad \forall j \end{aligned}$$

Solving this problem using constraint programming entails the same step already taken in section 5.6. The payoff matrix becomes a 4 by 4 table which diagonal elements compose the coordinates of the z^{**} ideal vector in the R^4 dimensional criterion space. The redundant character of output and employment can be seen in the table hereunder. It follows from the optimization program implemented in the previous section that there is a one-to-one correspondence in the trade-off between output and labor income and between employment and labor income. Moreover, they appear to be a strong conflict between the optimization of tax revenues and employment. The latter indeed takes one of its worst values when the negative impact of budget cuts on indirect business taxes is minimized. Only when labor income is individually optimized employment takes a lower value.

From the perspective of policy-making, those are two distressing findings. During a period of economic crisis, employment is a key preoccupation of state government officials but as the crisis progresses and impacts the health of the state public finances, priorities progressively shift toward managing fiscal stress. In order to do so, preserving the tax base is crucial. However, the SAM-MOLP model tells us that this is not possible if the decision maker wants to cushion the deterioration of the labor market.

As for the fact that employment suffers when labor income is optimized, it may be explained through mechanisms such as lengthened working hours for current employees. That is, as labor income increases, employers become more reluctant to recruit. In quantitative terms, minimizing the minimum impact of the fiscal

retrenchment policy on labor income causes a loss of approximately 1% in employment compared with is optimal value.

Table 5.12. The payoff matrix for a four-objective constraint program

	Tax (τ)	Labor income (ω)	Output (γ)	Employment (v)
Max $Z_1 = \tau$	-1,161,526.7	-9,714.0	-10,535.7	-20,326.2
Max $Z_2 = \omega$	-1,547,919.5	-9,602.6	-10,531.2	-20,397.9
Max $Z_3 = \gamma$	-1,349,004.3	-9,737.1	-10,465.8	-20,184.1
Max $Z_4 = v$	-1,349,004.3	-9,737.1	-10,465.8	-20,184.1

5.8.2 Introducing the Weighted Sum Method

Once these observations have been made, the next step of goal programming consists in the systematic analysis of the Pareto frontier. However, the fact that the criterion space has four dimensions makes the endeavor particularly challenging. We have already seen in chapter III that there existed a number of promising techniques to tackle an exponentially growing set of Pareto efficient solutions: the augmented weighted Tchebycheff procedure was one of them, but it suffers from exponential complexity as the number of constraints increases. A useful alternative may be found in general scalarization methods, which we introduced in section 4.3.3 using a weighted global criterion method. The most popular and straightforward approach to multiobjective optimization remains however the weighted sum method:

$$U = \sum_{i=1}^4 \alpha_i Z_i(x)$$

where U is an achievement function, $Z_i(x) \in S$ is a vector of objective functions and ϖ_i is a vector of weights chosen by the decision maker such that $\sum_{i=1}^4 \alpha_i = 1$ and $\alpha > 0$.

One can see that this formula is just a particular form of the general weighted exponential sum utility function (Koski and Silvennoinen, 1987):

$$U = \sum_{i=1}^k \alpha_i [Z_i(x)]^p, \quad Z_i(x) > 0 \quad \forall i$$

with p , a value reflecting the importance accorded to optimizing a particular function, is set to 1.

Two problems emerge from such formulation of a multiobjective optimization problem. The first issue is that the selected objectives can be measured in different units. $Z_i(x)$ must therefore be normalized for all i 's, so that the aggregative achievement function U actually makes sense (Kim and de Weck, 2004). We then have:

$$\bar{Z}_i = \frac{Z_i - Z_i^{**}}{Z_i^{Nadir} - Z_i^{**}}$$

The formulas for the normalized objective functions are presented in table 5.13. Notice that the denominator is a constant and that the only element allowed to vary – and linked to the social accounting matrix – is z_i . As usual, the problem is made more difficult to grasp by its location in the lower left orthant. Theoretically, the normalized

objective functions are comprised between 1 (corresponding to the ideal vector z_i^{**}) and 0 (corresponding to the Nadir point). In our case, they span the range $-1 \leq \bar{Z}_i \leq 0$, with -1 the most desirable value.

Table 5.14. The normalized objective functions for the implementation of the weighted sum method

	<i>Numerator</i>	<i>Denominator</i>	<i>Quotient</i>
Normalized output	$\gamma - \gamma^{**}$	$y^{Nadir} - \gamma^{**}$	$\bar{\gamma}$
Normalized labor income	$\omega - \omega^{**}$	$\omega^{Nadir} - \omega^{**}$	$\bar{\omega}$
Normalized employment	$v - v^{**}$	$v^{Nadir} - v^{**}$	\bar{v}
Normalized tax	$\tau - \tau^{**}$	$\tau^{Nadir} - \tau^{**}$	$\bar{\tau}$

The second and principal difficulty is to select properly the weights α_i (Voogd, 1983). Even if weights are correctly attributed, nothing guarantees that the final solution reached will actually satisfy the decision maker (Messac, 1996). Moreover, varying the weights to obtain a picture of the Pareto front is somewhat problematic because the resulting points may not spread evenly on the surface (Das and Dennis, 1997). In economic policy making, where the respective importance of the different objective functions is often difficult to assess, the best method to obtain weights was perhaps proposed by Wierzbicki (1986). It is however difficult to implement.

Keeping this in mind, we will postulate that the Governor of New York State is agnostic with respect to growth, employment, labor income and tax revenues, so that $\alpha_i = 0.25$. The Excel spreadsheet hosting our initial model can easily be transformed to perform an optimization of the achievement function U given the weights attributed to each of its four components. The advantage of having an aggregate function is that

it becomes easier to compare the gain in efficiencies realized through optimization.

For instance, we have that:

$$U_{DRP} = -0.36 > -0.63 = U_{MAX}^{\alpha_i=.25}$$

The left-hand side of the expression records the overall efficiency of the Deficit Reduction Plan with respect to the Nadir Point, i.e. 0). It can be interpreted that *ceteris paribus* the DRP is 36% more efficient than the worst budget cuts combination possible. The right-hand side informs us of the performance of the optimization program. Given an agnostic Governor, the model performs 63% better than it does at the Nadir point. The details of the vector solution s as follow:

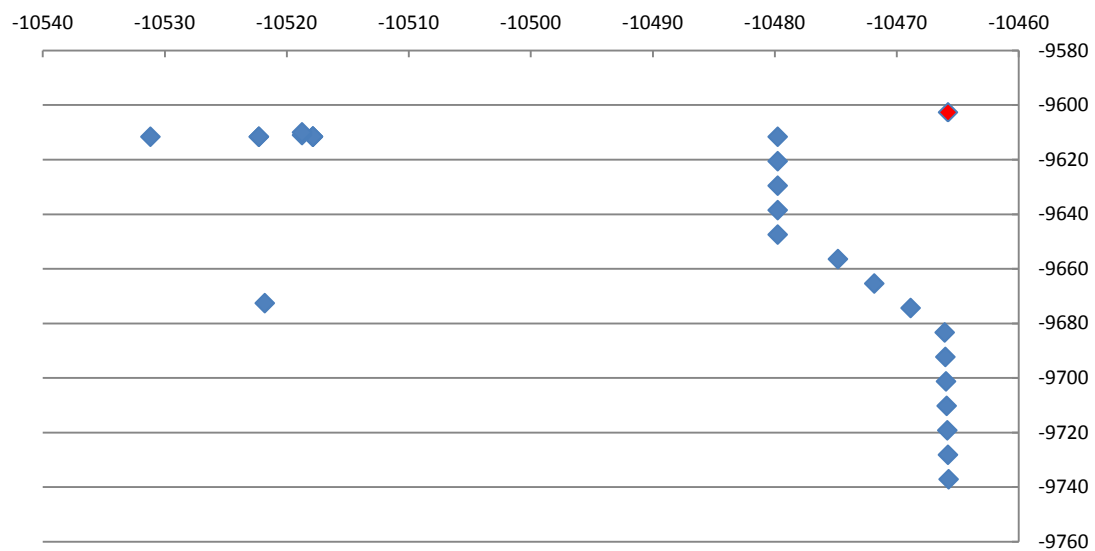
Table 5.15. Efficiency gains from a weighted sum optimization (\$ in millions)

Objective	Budget cut size		
	DRP	Solution vector	Difference
Output/Employment	-10,521.8	-10,465.8	56
Labor income	-9,672.6	-9,737.1	-64.5
Employment	-20,330	-20,184.1	145.9
Indirect business tax	-1,356	-1,349	27

If there seems to be a consequent gain in efficiency under the existing set of preferences of the policy maker, the results are less clear cut when it comes to the question of Pareto optimality. Indeed, one can see from table 5.14 that the solution vector reached by the weighted sum method is actually worse than the DRP with respect to labor income. We can thus conclude that the solution vector does not dominate the Deficit Reduction Plan in the R^4 criterion space. This can be explained by the one-to-one correspondence between output and employment, which gives them a heavy weight (0.5) compared to labor income and indirect business tax. It is also

possible that some subsets of the Pareto optimal region for this problem are non-convex. A short investigation supports this hypothesis. Building an optimization based on the constrained optimization of output – labor income being relegated to the rank of a constraint – we see that the behavior of the Pareto front is quite erratic, and that the weighted sum algorithm may be stuck at a local Pareto optimum.

Figure 5.7. The Pareto front for a two-objective fiscal retrenchment problem



This is an excellent illustration of the limits of the weighted sum method. Despite its relative simplicity, attributing non-arbitrary weights to the objective functions to obtain a good picture of the Pareto front is a challenging task. The best method to escape this pitfall is to generate a large number of solution vector using randomized weights.

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Chapter VI

CONCLUSION AND FURTHER RESEARCH

This dissertation was built on the assumptions that policy decisions, in particular when they come to the management of the budget, are better represented through multiple criteria than through traditional welfare functions. Indeed, we argued that policy-makers typically evolve in complex environments which contribute to shape their preferences and objectives. These preferences and objectives often turn out to be conflicting, rendering classical monobjective optimization powerless. The second assumption, made abundantly explicit by the tools we selected to carry out this research project, was that numerous policies can be considered inefficient from the perspective of mathematical optimization. We thus set out to combine a Walrasian general equilibrium model under the form of a social accounting matrix to techniques developed in the field of multiobjective linear programming. It was demonstrated in the fourth chapter that the approach is theoretically intriguing and particularly appealing given the numerous types of vector optimization in existence. We firstly introduced the augmented weighted Tchebycheff procedure to support decision-making.

In the spirit of this “distance-to-a-reference-objective” method, a constraint programming model was implemented to optimize the structure of mid-year budget cuts in New York State and limit their depressive effect on growth, employment and

labor income. The approach was completed by a short venture in the realm of genetic algorithms and scalarization techniques. We have also argued in favor of the use of a social accounting matrix to model the economy of New York State and to capture the equilibrium impact on several variables of changes in the values of the policy instruments.

The previous chapters contribute to the literature inasmuch as, to the extent of our knowledge, they constitute the first attempt made at combining systematically not only linear programming and social accounting matrix for investigating non-environmental policy issues but also multicriteria decision making and SAM in a theoretical and operational framework. The methodological approach we chose to develop throughout this dissertation differs significantly from previous empirical work on fiscal policy, which usually relies on Structural Vector Autoregressions. SVAR models have suffered from several shortcomings however, principally because of their source of identification and their over-reliance on exceptional events – in particular wars – when simulating shocks to government spending. It would be a particularly interesting exercise to combine the two techniques and observe whether or not the optimal solutions yielded by the SAM-MOLP model correspond to satisfying results when modeled through SVARs.

With respect to results, several goals were accomplished. First, it appears that a model can indeed be built on the basis of these two frameworks. Second, the model has been shown to be helpful in guiding decision makers toward the elaboration of efficient

policies, particularly with respect to the alleviation of certain negative effects they can have on selected macroeconomic variables. The magnitude of the amelioration generated by the optimization program is nonetheless relatively small. We purported that this might be due to the use of the IMPLAN social accounting matrix and its supporting database. In this respect, developing a customized SAM is critical.

Perhaps, however, the confinement of this dissertation to a strict and narrow economic approach to public policy prevented the extension of the framework elaborated in these pages to both social and political dimensions. Especially concerning the former the social accounting matrix could have been more comprehensively mobilized. This certainly opens the way to further research. As for the political side, we believe that the SAM-multiobjective linear programming model is helpful to assess the “space of possibilities” of a particular policy. The set of Pareto optimal solutions identified by the optimization algorithm offers a view of the directions where the policy should bent, and interaction between the decision maker and the analyst certainly can help to improve the assumption of the model.

The study of the management of mid-year budget gaps proposed in Chapter V raised many questions for complementary research:

- (i) The social accounting matrix, although defended in this thesis as an appropriate structural economic model to explore the short to mid-term impact of public policies on the economy of New York, works only when a

number of stringent assumptions are made. It would be beneficial to extend the model to a fully-fledged computable general equilibrium. The foundations for this line of research have been laid by André et al. (2010). In general and concerning the economic modeling dimension of our model, it is clear that the axis of research should follow the progressive relaxation of the assumptions we made for the social accounting matrix. This is for instance clearly the case when it comes to the representation of the state government and its tax policy. Public policy is also very much concerned with employment, and the IMPLAN framework is clearly unsatisfying to tackle this issue. Once again, the development of a CGE model incorporating a realistic labor market would come handy.

- (ii) In the debate over fiscal policy, the place of rational expectations and time-related decisions has become central. Employing the static SAM/CGE model with other dynamic tools, such as those offered by econometrics, would allow further refinement of the framework and a better sense of how the economy may move from one equilibrium to the other.
- (iii) Focusing on the model presented in this dissertation, a number of variables or parameters would benefit from certain improvements. For instance, as we explained in the case of the Deficit Reduction Plan proposed by Governor Paterson, the amount of budget cuts that must effectively be realized is actually less clear than what it can appear at first. Therefore,

allowing the budget constraints to display fuzziness would be an important step in the good direction (Kahraman, 2008; Sakawa et al., 2011). Moreover, stochasticity could be used to render the direct impact variables (employment, labor income or even output) more realistic.

Another area of improvement is the social accounting matrix itself. One of the most attractive feature of this framework is indeed the possibility of customizing it to the needs of the research. By using a pre-constructed SAM from IMPLAN, we have given up on the possibility to formulate the model such that it displays an advanced level of disaggregation in the sector of interest, primarily state and local governments. A disaggregation scheme that would lead to, we believe, better insight and more precision in the policy simulation outcomes is proposed for instance in Thorbecke (1988).

Finally, this dissertation relied on simplifications in modeling the objectives that animate policy maker. Policies are as rarely determined by a unique criterion as by two conflicting criteria. Jumping to three-dimensional Euclidean space however comes at a heavy computational price and poses numerous technical difficulties. Moreover, it is unclear whether or not adding layers of complexity over the relatively basic framework would be an improvement in view of the original purpose of this dissertation. The goal was indeed to provide policy-makers with a supporting tool to orient decision making. It is thus different from creating a model which aims at simulating the behavior of the economy.

In anyway, it is clear that the social accounting matrix multiobjective linear programming model should be extended and tailored to fit the particular situations in which it is deployed, always keeping in mind that no single model is exclusive of others and that quantitative/qualitative results should always be assessed critically.